Technical Handbook

ESAB

Stainless Steel Welding

WELDING CONSUMABLES FOR JOINING AND CLADDING
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Covered electrodes for MMA welding

	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others	FN
OK 61.20	EN 1600	E 19 9 L R 1 1	A5.4	E308L-16	0.026	0.7	0.7	19.2	9.6		0.10		5
OK 61.25	EN 1600	E 19 9 H B 2 2	A5.4	E308H-15	0.06	0.03	1.7	18.8	9.8		0.05		4
OK 61.30	EN 1600	E 19 9 L R 1 2	A5.4	E308L-17	0.03	0.9	0.7	19.3	10.0		0.09		4
OK 61.35	EN 1600	E 19 9 L B 2 2	A5.4	E308L-15	0.04	0.3	1.6	19.5	9.8		0.06		6
OK 61.35 Cryo	EN 1600	E 19 9 L B 2 2	A5.4	E308L-15	0.04	0.3	1.6	18.7	10.5		0.06		3
OK 61.50	EN 1600	E 19 9 H R 1 2	A5.4	E308H-17	0.05	0.7	0.7	19.8	10.0		0.10		4
OK 61.80	EN 1600	E 19 9 Nb R 1 2	A5.4	E347-17	0.03	0.7	0.6	19.5	10.0		0.09	Nb: 0.29	7
OK 61.81	EN 1600	E 19 9 Nb R 3 2	A5.4	E347-16	0.06	0.7	1.7	20.2	9.7		0.08	Nb: 0.72	5
OK 61.85	EN 1600	E 19 9 Nb B 2 2	A5.4	E347-15	0.04	0.4	1.7	19.5	10.2		0.07	Nb: 0.61	5
OK 61.86	EN 1600	E 19 9 Nb R 1 2	A5.4	E347-17	<0.03	0.8	0.7	19.0	10.4		0.09	Nb: 0.50	4
OK 62.53					0.07	1.6	0.6	23.1	10.4		0.16		8
OK 63.20	EN 1600	E 19 12 3 L R 1 1	A5.4	E316L-16	0.02	0.7	0.7	18.4	11.5	2.8	0.11		4
OK 63.30	EN 1600	E 19 12 3 L R 1 2	A5.4	E316L-17	0.02	0.8	0.6	18.1	11.0	2.7	0.10		6
OK 63.34	EN 1600	E 19 12 3 L R 1 1	A5.4	E316L-16	0.02	0.8	0.8	18.7	11.8	2.8	0.13		6
OK 63.35	EN 1600	E 19 12 3 L B 2 2	A5.4	E316L-15	0.04	0.4	1.6	18.3	12.6	2.7	0.06		4
OK 63.41	EN 1600	E 19 12 3 L R 5 3	A5.4	E316L-26	0.03	0.8	0.7	18.2	12.5	2.8	0.09		4
OK 63.80	EN 1600	E 19 12 3 Nb R 3 2	A5.4	E318-17	0.02	0.8	0.6	18.2	11.5	2.9	0.08	Nb: 0.31	7
OK 63.85	EN 1600	E 19 12 3 Nb B 4 2	A5.4	E318-15	0.04	0.5	1.6	17.9	13.0	2.7	0.06	Nb: 0.55	4
OK 64.30	EN 1600	E 19 13 4 N L R 3 2	A5.4	E317L-17	0.02	0.7	0.7	18.4	13.1	3.6	0.08		8
OK 64.63	EN 1600	E 18 16 5 N L R 3 2			0.04	0.4	2.5	17.8	16.4	4.7	0.17		0
OK 67.13	EN 1600	E 25 20 R 1 2	A5.4	E310-16	0.12	0.5	1.9	25.6	20.5				0
OK 67.15	EN 1600	E 25 20 B 2 2	A5.4	E310-15	0.10	0.4	2.0	25.7	20.0				0
OK 67.20	EN 1600	E 23 12 2 L R 1 1	A5.4	(E309LMo-16)	0.02	1.1	0.8	22.9	13.1	2.9	0.13		15
OK 67.43	EN 1600	E 18 8 Mn B 1 2	A5.4	(E307-16)	0.08	0.8	5.4	18.4	9.1				0
OK 67.45	EN 1600	E 18 8 Mn B 4 2	A5.4	(E307-15)	0.09	0.3	6.3	18.8	9.1				<5
OK 67.50	EN 1600	E 22 9 3 N L R 3 2	A5.4	E2209-17	0.03	0.9	1.0	22.6	9.0	3.0	0.16		35
OK 67.51	EN 1600	E 22 9 3 N L R 5 3	A5.4	E2209-26	0.03	0.8	0.7	22.7	8.9	3.0	0.16		40
OK 67.52	EN 1600	E 18 8 Mn B 8 3	A5.4	(E307-25)	0.09	0.9	7.0	17.7	8.5				<3
OK 67.53	EN 1600	E 22 9 3 N L R 1 2	A5.4	(E2209-16)	0.03	1.0	0.7	23.7	9.3	3.4	0.16		35
OK 67.55	EN 1600	E 22 9 3 N L B 2 2	A5.4	E2209-15	0.03	0.7	1.0	23.2	9.4	3.2	0.17		40
OK 67.60	EN 1600	E 23 12 L R 3 2	A5.4	E309L-17	0.03	0.8	0.9	23.7	12.4		0.09		15
OK 67.62	EN 1600	E Z 23 12 L R 7 3	A5.4	E309-26	0.04	0.8	0.6	23.7	12.7		0.09		15
OK 67.70	EN 1600	E 23 12 2 L R 3 2	A5.4	E309L-17	0.02	0.8	0.6	22.5	13.4	2.8	0.08		18
OK 67.71	EN 1600	E 23 12 2 L R 5 3	A5.4	E309LMo-26	0.04	0.9	0.9	22.9	13.3	2.6	0.08		15
OK 67.75	EN 1600	E 23 12 L B 4 2	A5.4	E309L-15	0.04	0.3	0.2	23.5	12.9				15
OK 68.15	EN 1600	E 13 B 4 2	A5.4	E410-15	0.04	0.4	0.3	12.9					
OK 68.17	EN 1600	E 13 4 R 3 2	A5.4	E410NiMo-16	0.02	0.4	0.6	12.0	4.6	0.6			
OK 68.25	EN 1600	E 13 4 B 4 2	A5.4	E410NiMo-15	0.04	0.4	0.6	12.2	4.5	0.6			
OK 68.37	NF A 81-383	E Z 17.4.1.B 20			0.05	0.16	1.1	16.0	5.0	0.43			
OK 68.53	EN 1600	E 25 9 4 N L R 3 2	A5.4	E2594-16	0.03	0.6	0.7	25.2	10.3	4.0	0.25		39
OK 68.55	EN 1600	E 25 9 4 N L B 4 2	A5.4	E2594-15	0.03	0.6	0.9	25.2	10.4	4.3	0.24		45

	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others	FN
OK 68.81	EN 1600	E 29 9 R 3 2	A5.4	E312-17	0.13	0.7	0.9	28.9	10.2				50
OK 68.82	EN 1600	E 29 9 R 3 2	A5.4	(E312-17)	0.13	1.1	0.6	29.1	9.9				50
OK 69.25	EN 1600	E 20 16 3 Mn N L B 4 2	A5.4	E316LMn-15	0.04	0.5	6.5	19.0	16.0	3.0	0.15		<0.5
OK 69.33	EN 1600	E20 25 5 Cu N L R 3 2	A5.4	E385-16	0.03	0.5	1.0	20.5	25.5	4.8	0.08	Cu: 1.7	0
OK 310Mo-L	EN 1600	E 25 22 2 N L R 1 2	A5.4	(E310Mo-16)	0.038	0.4	4.4	24.2	21.7	2.4	0.14		0
OK 92.05	EN ISO 14 172	E Ni 2061 (NiTi3)	A5.11	ENi-1	0.04	0.7	0.4		96.0			Ti: 1.5, Al: 0.10, Fe: 0.4	
OK 92.15	EN ISO 14 172	E Ni 6133 (NiCr16Fe12NbMo)	A5.11	ENiCrFe-2	0.03	0.45	2.7	16.1	69.0	1.9		Nb: 1.9, Fe: 7.7	
OK 92.18	EN ISO 1071	E C Ni-CI 3	A5.15	ENi-CI	1.0	0.6	0.8		94.0			Fe: 4	
OK 92.26	EN ISO 14 172	E Ni 6182 (NiCr15Fe6Mn)	A5.11	ENiCrFe-3	0.03	0.5	6.6	15.8	66.9			Nb: 1.7, Fe: 8.8	
OK 92.35	EN 14 700	E Z Ni2	A5.11	(ENiCrMo-5)	0.05	0.5	0.9	15.5	57.5	16.4		W: 3.5, Fe: 5.5	
OK 92.45	EN ISO 14 172	E Ni 6625 (NiCr22Mo9Nb)	A5.11	ENiCrMo-3	0.03	0.4	0.2	21.7	63.0	9.3		Nb: 3.3, Fe: 2.0	
OK 92.55	EN ISO 14 172	E Ni 6620 (NiCr14Mo7Fe)	A5.11	ENiCrMo-6	0.05	0.3	3.0	12.9	69.4	6.2		Nb: 1.3, W: 1.6, Fe: 5.0	
OK 92.58	EN ISO 1071	E C NiFe-CI-A 1	A5.15	ENiFe-CI-A	1.5	0.7	0.8		51.0			Al: 1.4, Fe: 46	
OK 92.59	EN ISO 14 172	E Ni 6059 (NiCr23Mo16)	A5.11	ENiCrMo-13	0.01	0.2	0.2	22.0	61.0	15.2		W: 0.25, Fe: 0.8	
OK 92.60	EN ISO 1071	E C NiFe-1 3	A5.15	ENiFe-CI	0.9	0.5	0.6	53.0				Fe: 44, Cu: 0.9, Al: 0.4	
OK 92.78	EN ISO 1071	E C NiCu 1			0.35		0.9		65.0			Cu: 32, Fe: 2.2	
OK 92.86	EN ISO 14 172	E Ni 4060 (NiCu30Mn3Ti)	A5.11	ENiCu7	0.01	0.3	2.1		66.0			Cu: 29, Fe: 1.6, Ti: 0.2	
OK 94.25	DIN 1733	EL-CuSn7					0.35					Cu: 93, Sn: 6.5	

Solid wires for MIG/MAG welding

	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others	FN
OK Autrod 308H	EN ISO 14343	G 19 9 H	A5.9:	ER308H	0.04	0.4	1.8	19.5	9.0				
OK Autrod 308L	EN ISO 14343	G 19 9 L	A5.9:	ER308L	0.02	0.4	1.6	20.0	10.0	0.05	<0.08		5-10
OK Autrod 308LSi	EN ISO 14343	G 19 9 LSi	A5.9:	ER308LSi	0.01	0.8	1.8	20.0	10.0	0.1	<0.08		8
OK Autrod 309L	EN ISO 14343	G 23 12 L	A5.9:	ER309L	0.03	0.4	1.5	23.5	13.0	0.1	<0.11		9
OK Autrod 309LSi	EN ISO 14343	G 23 12 LSi	A5.9:	ER309LSi	0.02	0.8	1.8	24.0	13.0	0.1	<0.09		8
OK Autrod 309MoL	EN ISO 14343	G 23 12 L	A5.9:	(ER309MoL)	0.01	0.3	1.8	21.5	14.5	2.6			8
OK Autrod 310	EN ISO 14343	G 25 20	A5.9:	ER310	0.10	0.4	1.7	25.0	20.0				
OK Autrod 312	EN ISO 14343	G 29 9	A5.9:	ER312	0.10	0.5	1.7	29.0	8.5				
OK Autrod 316L	EN ISO 14343	G 19 12 3 L	A5.9:	ER316L	0.02	0.4	1.8	18.5	12.0	2.5	<0.08		8
OK Autrod316LSi	EN ISO 14343	G 19 12 3 LSi	A5.9:	ER316LSi	0.02	0.8	1.8	18.5	12.0	2.5	<0.08		7
OK Autrod 318Si	EN ISO 14343	G 19 12 3 Nb	A5.9:	ER318	0.08	0.8	1.5	19.0	12.0	2.7	<0.08	Nb: 0.7	7
OK Autrod 347Si	EN ISO 14343	G 19 9 Nb	A5.9:	ER347	0.04	0.7	1.7	19.0	9.8	0.1	<0.08	Nb: 0.6	5-10
OK Autrod 385	EN ISO 14343	G 20 25 5 Cu L	A5.9:	ER385	0.01	0.3	1.6	20.0	25.0	4.7		Cu: 1.4	0
OK Autrod 410NiMo	EN ISO 14343	G 13 4			0.015	0.4	0.7	12.0	4.2	0.5	<0.3		
OK Autrod 430LNb	EN ISO 14343	G Z 17 L Nb			0.015	0.5	0.5	18.5	0.2	0.06	0.01	Nb>12xC	
OK Autrod 430Ti	EN ISO 14343	G Z 17 Ti			0.09	0.9	0.4	18.0	0.3	0.1		Ti: 0.3	
OK Autrod 16.95	EN ISO 14343	G 18 8 Mn			0.10	1.0	6.5	18.5	8.5	0.1	<0.08		
OK Autrod 2209	EN ISO 14343	G 22 9 3 N L	A5.9:	ER2209	0.01	0.6	1.6	23.0	9.0	3.0	0.1		45
OK Autrod 2307					0.02	0.4	0.5	23	7.0	<0.5	0.14		40
OK Autrod 2509	EN ISO 14343	G 25 9 4 N L		-	0.01	0.35	0.4	25.0	9.8	4.0	0.25		40
OK Autrod 19.81	EN ISO 18274	G Ni6059 (NiCr23Mo16)	A5.14:	ERNiCrMo-13	0.002	0.03	0.15	22.7	bal	15.4		Al: 0.15	
OK Autrod 19.82	EN ISO 18274	G Ni6625 (NiCr22Mo9Nb)	A5.14:	ER NiCrMo-3	0.01	0.1	0.1	22.0	bal	9.0		Nb+Ta: 3.65, Fe<2	
OK Autrod 19.85	EN ISO 18274	G Ni6082 (NiCr20Mn3Nb)	A5.14:	ERNiCr-3	0.02	0.1	3.0	20.0	bal			Nb+Ta: 2.5, Ti<3	
OK Autrod 19.92	EN ISO 18274	G Ni 2061 (NiTi3)	A5.14	ERNi-1	0.02	0.3	0.4		93.0			Ti: 3	
OK Autrod 19.93	EN ISO 18274	G Ni 4060 (NiCu30Mn3Ti)	A5.14	ERNiCu-7	0.03	0.3	3.0		64.0			Cu: 28, Ti: 2	

Overview stainless steel consumables

Wires for TIG welding

OK Tigrod	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others	FN
308H	EN ISO 14343	G 19 9 H	A5.9:	ER308H	0.05	0.4	1.8	20	9.3			Tot<0.5	
308L	EN ISO 14343	G 19 9 L	A5.9:	ER308L	0.01	0.4	1.6	20.0	10.0	0.1	<0.08	Tot<0.5	9
308LSi	EN ISO 14343	G 19 9 LSi	A5.9:	ER308LSi	0.01	0.8	1.8	20.0	10.0	0.1	<0.08	Tot<0.5	8
309L	EN ISO 14343	G 23 12 L	A5.9:	ER309L	0.02	0.4	1.6	24.0	13.0	0.1	<0.11	Tot<0.5	9
309LSi	EN ISO 14343	G 23 12 Lsi	A5.9:	ER309LSi	0.02	0.8	1.8	23.0	13.0	0.1	<0.09	Tot<0.5	9
309MoL	EN ISO 14343	G 23 12 L	A5.9:	(ER309MoL)	0.01	0.3	1.6	22.0	14.5	2.7		Tot<0.5	8
310	EN ISO 14343	G 25 20	A5.9:	ER310	0.10	0.4	1.7	25.0	20.0			Tot<0.5	
312	EN ISO 14343	G 29 9	A5.9:	ER312	0.10	0.5	1.7	29.0	9.0			Tot<0.5	
316L	EN ISO 14343	G 19 12 3 L	A5.9:	ER316L	0.01	0.4	1.6	18.5	12.0	2.5	<0.08	Tot<0.5	8
316LSi	EN ISO 14343	G 19 12 3 LSi	A5.9:	ER316LSi	0.01	0.8	1.7	18.0	0.3	0.1	<0.08	Tot<0.5	7
318Si	EN ISO 14343	G 19 12 3 Nb	A5.9:	ER318	0.04	0.8	1.5	19.0	12.5	2.5	<0.08	Nb=0.5	7
347Si	EN ISO 14343	G 19 9 Nb	A5.9:	ER347	0.04	0.8	1.5	20.0	10.0	0.1	<0.08	Nb=0.7	7
385	EN ISO 14343	G 20 25 5 Cu L	A5.9:	ER385	0.01	0.4	1.8	20.0	25.0	4.5		Cu=1.5	0
410NiMo	EN ISO 14343	G 13 4			0.01	0.3	0.7	12.3	4.5	0.5	<0.3	Tot<0.5	
430Ti	EN ISO 14343	G Z 17 Ti			0.09	0.7	0.4	17.5	<0.4	<0.3		Ti=0.5	
16.95	EN ISO 14343	G 18 8 Mn			0.08	0.7	6.5	18.5	8.5	0.1	<0.08	Tot<0.5	
2209	EN ISO 14343	G 22 9 3 N L	A5.9:	ER2209	0.01	0.5	1.6	22.5	8.5	3.2	0.15	Tot<0.5	45
2509	EN ISO 14343	G 25 9 4 N L	A5.9:	-	<0.02	0.35	0.4	25.0	9.8	4.0	0.25		40
19.81	EN ISO 18274	G Ni6059 (NiCr23Mo16)	A5.14:	ERNiCrMo-13	0.002	0.03	0.15	22.7	bal	15.4		Al=0.15	
19.82	EN ISO 18274	G Ni6625 (NiCr22Mo9Nb)	A5.14:	ER NiCrMo-3	0.02	0.1	0.1	22.0	bal	9.0		Nb+Ta=3.65, Fe<2	
19.85	EN ISO 18274	G Ni6082 (NiCr20Mn3Nb)	A5.14:	ERNiCr-3	<0.1	<0.5	3.0	20.0	>67			Nb+Ta=2.5, Ti<3	
19.92	EN ISO 18274	G Ni 2061 (NiTi3)	A5.14	ERNi-1	0.02	0.1	0.4		93.0			Ti=3	
19.93	EN ISO 18274	G Ni 4060 (NiCu30Mn3Ti)	A5.14	ERNiCu-7	0.03	0.3	3.0		64.0			Cu=28, Ti=2, Fe=2	

Tubular cored wires for MIG/MAG welding

	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others
Shield-Bright 308L X-tra	EN ISO 17633-A	T 19 9 L R C 3 / T 19 9 L R M 3	A5.22	E308LT0-1 / E308LT-4	0.02	0.9	1.4	19.6	9.9	0.1		
Shield-Bright 309L X-tra	EN ISO 17633-A	T 23 12 L R C 3 / T 23 12 L R M 3	A5.22	E309LT0-1 / E309LT0-4	0.03	0.8	1.4	24.5	12.5	0.1		
Shield-Bright 309LMo X-tra	EN ISO 17633-A	T 23 12 2 L R C 3 / T 23 12 2 L R M 3	A5.22	E309LMoT0-1 / E309LMoT0-4	0.03	0.8	1.2	23.5	13.5	2.5		
Shield-Bright 316L X-tra	EN ISO 17633-A	T 19 12 3 L R C 3 / T 19 12 3 L R M 3	A5.22	E316LT0-1 / E316LT0-4	0.03	0.6	1.3	18.5	12.0	2.7		
Shield-Bright 317L X-tra			A5.22	E317LT0-1 / E317LT0-4	0.03	0.7	1.5	19.0	12.0	3.5		
Shield-Bright 347 X-tra	EN ISO 17633-A	T 19 9 Nb R M 3	A5.22	E347T0-1 / E347T0-4	0.04	0.5	1.6	19.0	9.6	0.1		Nb:0.8
Shield-Bright 308L	EN ISO 17633-A	T 19 9 L P M 2 / T 19 9 L P C 2	A5.22	E308LT1-1 / E308LT1-4	0.03	0.9	1.2	19.0	10.0	0.1		
Shield-Bright 309L	EN ISO 17633-A	T 23 12 L P C 2 / T 23 12 L P M 2	A5.22	E309LT1-1 / E309LT1-4	0.03	0.9	1.3	24.0	12.5	0.1		
Shield-Bright 309LMo			A5.22	E309LMoT1-1 / E309LMoT1-4	0.03	0.8	1.2	23.5	13.5	2.5		
Shield-Bright 316L	EN ISO 17633-A	T 19 12 3 L P M 2 / T 19 12 3 L P C 2	A5.22	E316LT1-1 / E316LT1-4	0.03	0.6	1.3	18.5	12.0	2.7		
Shield-Bright 317L			A5.22	E317LT1-1 / E317LT1-4	0.03	0.9	1.2	19.5	13.0	3.5		
Shield-Bright 347			A5.22	E347LT1-1 / E347LT1-4	0.03	0.9	1.2	19.5	10.0	0.1		
OK Tubrod 14.27	EN ISO 17633-A	T 22 9 3 N L P M 2 / T 22 9 3 N L P C 2	A5.22	E2209LT1-4 / E2209LT1-1	0.03	0.9	1.0	22.6	9.0	3.0	0.15	
OK Tubrod 14.28					0.03	0.6	0.9	25.2	9.2	3.9	0.25	
Shield-Bright 410 NiMo			A5.22	E410T1-4	0.01	0.7	0.5	11.3	4.1	0.5		
OK Tubrod 15.30	EN ISO 17633-A	T 19 9 L M M 2			0.02	0.7	1.3	18.8	9.8	0.1		
OK Tubrod 15.31	EN ISO 17633-A	T 19 12 3 L M M 2			0.02	0.7	1.2	17.6	11.6	2.7		
OK Tubrod 15.34	EN ISO 17633-A	T 18 8 Mn M M 2			0.10	0.7	6.7	18.5	8.7	0.1		

Wires for Submerged Arc Welding

	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others	FN
OK Autrod 308L	EN ISO 14343	S 19 9 L	A5.9:	ER308L	0.02	0.4	1.8	20.0	10.0	0.2	0.05		
OK Autrod 308H	EN ISO 14343	S 19 9 H	A5.9:	ER308H	0.05	0.5	1.7	21.0	10.0	0.2	0.04		
OK Autrod 347	EN ISO 14343	S 19 9 Nb	A5.9:	ER347	0.04	0.4	1.7	19.3	10.0	0.1	0.08	Nb: 0.8	
OK Autrod 316L	EN ISO 14343	S 19 12 3 L	A5.9:	ER316L	0.01	0.4	1.7	18.5	12.2	2.7	0.05		
OK Autrod 317L	EN ISO 14343	S 18 15 3 L	A5.9:	ER317L	0.01	0.4	1.7	19.0	13.5	3.6	0.05		
OK Autrod 316H	EN ISO 14343	S 19 12 3 H	A5.9:	ER316H	0.05	0.4	1.7	19.3	12.5	2.6	0.04		
OK Autrod 16.38	EN ISO 14343	S 20 16 3 Mn L	A5.9:	-	0.01	0.4	6.9	19.9	16.5	3.0	0.18		
OK Autrod 318	EN ISO 14343	S 19 12 3 Nb	A5.9:	ER318	0.04	0.4	1.7	18.5	11.5	2.5	0.08	Nb: 0.8	
OK Autrod 309L	EN ISO 14343	S 23 12 L	A5.9:	ER309L	0.01	0.4	1.7	23.4	13.4	0.1	0.05		
OK Autrod 309MoL	EN ISO 14343	S 23 12 L	A5.9:	(ER309MoL)	0.01	0.4	1.4	21.4	15.0	2.7	0.05		
OK Autrod 385	EN ISO 14343	S 20 25 5 Cu L	A5.9:	ER385	0.01	0.4	1.7	20.0	25.0	4.4	0.04	Cu: 1.5	
OK Autrod 310	EN ISO 14343	S 25 20	A5.9:	ER310	0.11	0.4	1.7	25.9	20.8	0.1	0.04		
OK Autrod 312	EN ISO 14343	S 29 9	A5.9:	ER312	0.10	0.4	1.8	30.3	9.3	0.2	0.04		
OK Autrod 2209	EN ISO 14343	S 22 9 3 N L	A5.9:	ER2209	0.01	0.5	1.6	23.0	8.6	3.2	0.16		
OK Autrod 310MoL	EN ISO 14343	S 25 22 2 N L	A5.9:	(ER310MoL)	0.01	0.1	4.5	25.0	21.9	2.0	0.14		
OK Autrod 2509	EN ISO 14343	S 25 9 4 N L	A5.9:	-	0.01	0.4	0.4	25.0	9.5	3.9	0.25		
OK Autrod 16.97	EN ISO 14343	S 18 8 Mn	A5.9:	(ER307)	0.07	0.5	6.5	18.5	8.2	0.1			
OK Autrod 19.81	EN ISO 18274	S Ni6059 (NiCr23Mo16)	A5.14:	ERNiCrMo-13	0.01	0.1	0.2	23.0	Bal.	16.0		Al: 0.3, Fe: 1.0	
OK Autrod 19.82	EN ISO 18274	S Ni6625 (NiCr22Mo9Nb)	A5.14:	ER NiCrMo-3	0.05	0.2	0.2	22.0	Bal.	9.0		Nb: 3.5, Fe≤1.0	
OK Autrod 19.83	EN ISO 18274	S Ni 6276 (NiCr15Mo16Fe6W4)	A5.14:	ER NiCrMo-4	0.01	0.05	0.8	15.5	Bal.	15.5		W: 4.0, Co: 2.0, Fe≤5.0	
OK Autrod 19.85	EN ISO 18274	S Ni6082 (NiCr20Mn3Nb)	A5.14:	ERNiCr-3	0.05	0.3	3.0	20.0	Bal.	0.1		Nb: 2.6, Fe≤1.0	

Strips for Submerged Arc Strip Cladding and Electroslag Strip Cladding

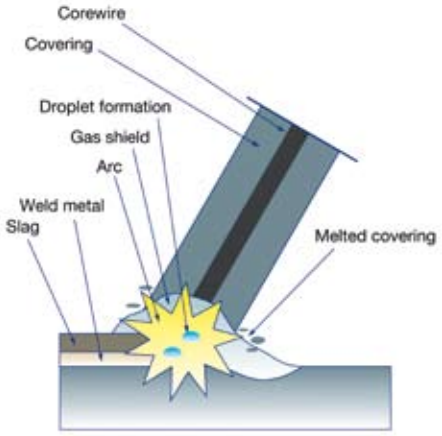
	Classification Euronorm		AWS/SFA		Typical chemical composition (%) C	Si	Mn	Cr	Ni	Mo	N	others	FN
OK Band 308L	EN ISO 14343	S 19 9 L	A5.9:	EQ308L	0.015	0.3	1.8	20.0	10.5		0.06		11
OK Band 347	EN ISO 14343	S 19 9 Nb	A5.9:	EQ347	0.02	0.4	1.8	19.5	10.0		0.06	Nb: 0.5	11
OK Band 316L	EN ISO 14343	S 19 12 3 L	A5.9:	EQ316L	0.02	0.4	1.8	18.5	13.0	2.9	0.06		8
OK Band 309L	EN ISO 14343	S 23 12 L	A5.9:	EQ309L	0.015	0.4	1.8	23.5	13.5		0.06		13
OK Band 309LNb	EN ISO 14343	S 23 12 L Nb			0.02	0.3	2.1	24.0	12.5		0.06	Nb: 0.8	22
OK Band 309L ESW					0.015	0.2	1.8	21.0	11.5		0.06		11
OK Band 309LNb ESW					0.015	0.2	1.8	21.0	11.0		0.06	Nb: 0.6	15
OK Band 309LMo ESW					0.015	0.2	1.8	20.5	13.5	2.9	0.06		13
OK Band 430	EN ISO 14343	S 17			0.04	0.4	0.7	17.0			0.06		
OK Band NiCr3	EN ISO 18274	S Ni6082 (NiCr20Mn3Nb)	A5.14:	ERNiCr-3	< 0.1	0.2	3.0	20.0	≥67.0		0.05	Nb: 2.5, Fe≤3.0	
OK Band NiCrMo3	EN ISO 18274	S Ni6625 (NiCr22Mo9Nb)	A5.14:	ER NiCrMo-3	< 0.1	0.1	0.3	22.0	≥58.0	9.0	0.05	Nb: 4.0, Fe≤2.0	

Consumable selection by parent material

EN Standard	Designation	No.	AISI (UNS)	Covered electrodes for MMA welding	Solid wires for MIG/MAG welding
FERRITIC					
EN 10088-1	X2CrNi12	1.4003	S41050	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X6Cr13	1.4000	403	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X6Cr17	1.4016	430	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X2CrMoTi18-2	1.4521	S44400	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	-	1.4762	446	OK 67.15	OK Autrod 310
AUSTENTIC					
EN 10088-1	X2CrNi18-9	1.4307	304L	OK 61.20, OK 61.30, OK 61.34, OK 61.35, OK 61.35 Cryo	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X10CrNi18-8	1.4310	301	OK 61.20, OK 61.30, OK 61.34, OK 61.35, OK 61.35 Cryo	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X2CrNiN18-10	1.4311	304LN	OK 61.20, OK 61.30, OK 61.34, OK 61.35, OK 61.35 Cryo	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X5CrNi18-10	1.4301	304	OK 61.20, OK 61.30, OK 61.34, OK 61.35, OK 61.35 Cryo	OK Autrod 308L, OK Autrod 308LSi
EN 10088-1	X8CrNiS18-9	1.4305	303	OK 68.81	OK Autrod 312
EN 10088-1	X6CrNiTi18-10	1.4541	321	OK 61.80, OK 61.81, OK 61.85, OK 61.86	OK Autrod 347Si
EN 10088-1	X6CrNiNb18-10	1.4550	347	OK 61.80, OK 61.81, OK 61.85, OK 61.86	OK Autrod 347Si
EN 10088-1	X3CrNiMo17-13-3	1.4436	316	OK 63.20, OK 63.30, OK 63,34, OK 63.35, OK 63.41	OK Autrod 316L, OK Autrod 316LSi
EN 10088-1	X5CrNiMo17-12-2	1.4401	316	OK 63.20, OK 63.30, OK 63,34, OK 63.35, OK 63.41	OK Autrod 316L, OK Autrod 316LSi
EN 10088-1	X2CrNiMo17-12-2	1.4404	316L	OK 63.20, OK 63.30, OK 63,34, OK 63.35, OK 63.41	OK Autrod 316L, OK Autrod 316LSi
EN 10088-1	X2CrNiMo18-14-3	1.4435	316L	OK 63.20, OK 63.30, OK 63,34, OK 63.35, OK 63.41	OK Autrod 316L, OK Autrod 316LSi
EN 10088-1	X2CrNiMoN17-13-3	1.4429	S31653	OK 63.20, OK 63.30, OK 63,34, OK 63.35, OK 63.41	OK Autrod 316L, OK Autrod 316LSi
EN 10088-1	X6CrNiMoTi17-12-2	1.4571	316Ti	OK 63.80, OK 63.85	OK Autrod 318Si
EN 10088-1	X6CrNiMoNb17-12-2	1.4580	316Nb	OK 63.80, OK 63.85	OK Autrod 318Si
EN 10088-1	X12CrMnNiN17-7-5	1.4372	201	OK 67.43, OK 67.45, OK 67.52	OK Autrod 16.95
EN 10088-1	X2CrNiMo18-14-3	1.4435	S31603	OK 69.25	
EN 10088-1	X1CrNiMoN25-22-2	1.4466	310MoLN	OK 310Mo-L	OK Autrod 310
EN 10088-1	X1NiCrMoCu25-20-5	1.4539	N08904	OK 69.33	OK Autrod 385, OK Autrod 19.82
EN 10088-1	X2CrNiMo18-15-4	1.4438	S31703	OK 64.30, OK 64.63	OK Autrod 385, OK Autrod 19.82
EN 10088-1	X1CrNiMoCuN20-18-7	1.4547	S31254	OK 92.45	OK Autrod 19.82
EN 10088-1	X1NiCrMoCu31-27-4	1.4563	N08028	OK 92.45	OK Autrod 19.81
EN 10088-1	-	1.4562	S32654	OK 92.59	OK Autrod 19.81
HEAT RESISTANT AUSTENITIC					
EN 10095	X15CrNi23-13	1.4833	309S	OK 67.70, OK 67.75	OK Autrod 309LSi, OK Autrod 309MoL
EN 10095	X8CrNi25-21	1.4845	310S24	OK 67.13, OK 67.15	OK Autrod 310
EN 10095	X9CrNiSiNCe21-11-2	1.4835	S30815	OK 62.53	
AUSTENITIC-FERRITIC					
EN 10088-1	-	1.4162	S32101	OK 67.50, OK 67.53, OK 67.55	OK Autrod 2209
EN 10088-1	X2CrNiN23-4	1.4362	S32304	OK 67.50, OK 67.53, OK 67.55	OK Autrod 2209
EN 10088-1	X2CrNiMoN22-5-3	1.4462	S31803	OK 67.50, OK 67.53, OK 67.55	OK Autrod 2209
EN 10088-1	X2CrNiMoN25-7-4	1.4410	S32750	OK 68.53, OK 68.55	OK Autrod 2509
EN 10088-1	X2CrNiMoCuWN25-7-4	1.4501	S32760	OK 68.53, OK 68.55	OK Autrod 2509

Wires for TIG welding	Tubular cored wires for MIG/MAG	Wires for SA welding
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 310		OK Autrod 310
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 308L, OK Tigrod 308LSi	Shield-Bright 308L, Shield-Bright 308L X-tra, OK Tubrod 15.30	OK Autrod 308L
OK Tigrod 312		OK Autrod 312
OK Tigrod 347Si	Shield-Bright 347	OK Autrod 347
OK Tigrod 347Si	Shield-Bright 347	OK Autrod 347
OK Tigrod 316L, OK Tigrod 316LSi	Shield-Bright 316L, Shield-Bright 316L X-tra, OK Tubrod 15.31	OK Autrod 316L
OK Tigrod 316L, OK Tigrod 316LSi	Shield-Bright 316L, Shield-Bright 316L X-tra, OK Tubrod 15.31	OK Autrod 316L
OK Tigrod 316L, OK Tigrod 316LSi	Shield-Bright 316L, Shield-Bright 316L X-tra, OK Tubrod 15.31	OK Autrod 316L
OK Tigrod 316L, OK Tigrod 316LSi	Shield-Bright 316L, Shield-Bright 316L X-tra, OK Tubrod 15.31	OK Autrod 316L
OK Tigrod 316L, OK Tigrod 316LSi	Shield-Bright 316L, Shield-Bright 316L X-tra, OK Tubrod 15.31	OK Autrod 316L
OK Tigrod 318Si		OK Autrod 318
OK Tigrod 318Si		OK Autrod 318
OK Tigrod 16.95		OK Autrod 16.97
OK Tigrod 310		OK Autrod 310MoL
OK Tigrod 385, OK Tigrod 19.82		OK Autrod 385, OK Autrod 19.82
OK Tigrod 385, OK Tigrod 19.82	Shield-Bright 317L, Shield-Bright 317L X-tra	OK Autrod 385, OK Autrod 19.82
OK Tigrod 19.82		OK Autrod 19.82
OK Tigrod 19.81		OK Autrod 19.81
OK Tigrod 19.81		OK Autrod 19.81
OK Tigrod 309LSi, OK Tigrod 309MoL	Shield-Bright 309L, Shield-Bright 309L X-tra	OK Autrod 309L
OK Tigrod 310		OK Autrod 310
OK Tigrod 2209	OK Tubrod 14.27	
OK Tigrod 2209	OK Tubrod 14.27	OK Autrod 2209
OK Tigrod 2209	OK Tubrod 14.27	OK Autrod 2209
OK Tigrod 2509		OK Autrod 2509
OK Tigrod 2509		OK Autrod 2509

Covered electrodes for MMA welding



Principle of manual metal arc werlding.

Over the last few decades a significant amount of applications that were traditionally welded with covered electrodes have been transferred to more productive methods such as submerged arc welding and flux cored arc welding. However, for applications where flexibility is essential, the covered electrode is often the best solution.

The covered electrode consists of a core wire and a coating which in combination fulfil several functions:

All weld metal

The core wire provides the weld metal and the coating provides the weld with additional alloying elements or iron powder.

Slag

Several components in the coating help form and control the slag, which protects, shapes and supports the weld pool during welding.

Gas shielding

Components in the coating generate a gas shield which protects the weld deposit from the surrounding atmosphere.

Deoxidants

These components in the coating are responsible for removing oxygen from the weld metal and are often added as ferro alloys such as ferro manganese and ferro silicon.

Arc stabilisers

Components in the coating that create ionisation in the arc, stabilising the arc.

Electrode types

Covered electrodes for stainless steel welding are catagorised according to their coating composition into rutile, basic and high deposition types.

Many welders prefer rutile types. They are easier to use, due to a smooth and stable arc on both AC and DC, minimal spatter and a very fine spray metal transfer. Striking properties are very good and the bead appearance and slag removal are excellent.

Basic types are usually used in more demanding applications e.g. high impact toughness at cryogenic temperatures and high restraint. The quick freezing weld metal offers exceptional good welding performance in all positions. Basic components in the coating provide a clean weld metal. Therefore, these types give the best protection against porosity and hot cracking.

High deposition electrodes are those containing high amounts of iron powder in the coating and are used to obtain high productivity. Deposition rates increase with the amount of iron powder in the coating. High deposition types have a recovery exceeding 130%. The weld pools are larger and welding is conducted only in a down hand or flat position.

Vertical down welding requires a specially coated electrode. A thin rutile coating provides excellent welding characteristics in vertical down welding of thin plate, with minimum distortion due to the high welding speed.

Packaging

VacPac
All ESAB stainless and nickel-based covered electrodes are supplied in VacPac vacuum packaging.

- ≤ 2.5mm: packed in quarter packs containing about 0.7kg each. Each carton contains 6 packages.
- 3.2mm: packed in half packs containing about 2kg each. Each carton contains 3 packages
- ≥ 4.0mm: packed in half packs containing about 2kg each. Each carton contains 3 packages

Plastic capsules
The main stainless types are also supplied in plastic capsules.

- ≤ 2.5mm: packed in quarter packs containing about 0.7kg each. Each carton contains 9 packages.
- ≥ 3.2mm: packed in half packs containing about 2kg each. Each carton contains 6 packages

VacPac is available in various packaging sizes to suit fabricators' individual consumption of MMA electrodes.

Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.20		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**
Type of coating Acid Rutile **Recovery** 105-108% **Redrying** 350°C/2h	EN 1600 E 19 9 L R 1 1 AWS/SFA 5.4 E308L-16	0.026	0.7	0.7	19.2	9.6		0.10		5

Rutile coated electrode for welding 19Cr10Ni -type steels. Also suitable for welding stabilised steels of similar composition, except when the full creep resistance of the base material is to be met. The electrode is especially designed for welding thin walled pipes. Diameters 1.6 - 2.5mm can be used in all positions including vertical down.

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.25		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**
Type of coating Basic **Recovery** 104% **Redrying** 200°C/2h	EN 1600 E 19 9 H B 2 2 AWS/SFA 5.4 E308H-15 Seproz	0.06	0.3	1.7	18.8	9.8		0.05		4

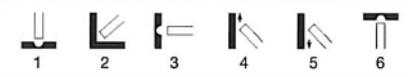
Basic coated stainless electrode of the 308H-type especially designed for high temperature applications.

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.30		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**
Type of coating Acid Rutile **Recovery** 105% **Redrying** 350°C/2h	EN 1600 E 19 9 L R 1 2 AWS/SFA 5.4 E308L-17 CSA W48 E308L-17 ABS, CE, CWB, DB, DNV, Seproz, TÜV	0.03	0.9	0.7	19.3	10.0		0.09		4

Extra low carbon stainless steel electrode for welding steels of the 19 Cr 10 Ni-type. Also suitable for welding stabilised stainless steels of similar composition, except when the full creep resistance of the base material is to be met.

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.35		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**
Type of coating Basic **Recovery** 100% **Redrying** 200°C/2h	EN 1600 E 19 9 L B 2 2 AWS/SFA 5.4 E308L-15 Seproz, TÜV	0.04	0.3	1.6	19.5	9.8		0.05		6

Basic stainless electrode of the 308L-type designed for positional welding such as piping. Suitable for applications where requirements concerning mechanical properties are demanding. Lateral expansion of min. 0.38 mm is met down to -120 °C.



Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
430	560	45	+20/70	1.6 x 300 2.0 x 300 2.5 x 300	23 - 40 25 - 60 28 - 85 DC+/AC/min. OCV: 50V	1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
430	600	45	+20/95	2.5 x 300 3.2 x 350 4.0 x 350	55 - 85 75 - 110 80 - 160 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
430	560	43	+20/70 -60/49	1.6 x 300 2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	35 - 45 35 - 65 50 - 90 70 - 130 90 - 180 140 - 250 DC+/AC/min. OCV: 50V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
460	610	40	+20/100 -120/70 -196/40	2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	55 - 85 80 - 120 80 - 180 160 - 210 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3

Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.35 Cryo		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**
Type of coating Basic **Recovery** 100% **Redrying** 200°C/2h	EN 1600 E 19 9 L B 2 2 AWS/SFA 5.4 E308L-15 TÜV	0.04	0.3	1.6	18.7	10.5		0.06		3

A basic stainless stick electrode of the 308L-type especially designed for cryogenic applications. Provides a controlled low ferrite content to ensure lateral expansion of min. 0.38 mm at -196°C.

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.50		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**
Type of coating Acid Rutile **Recovery** 101% **Redrying** 350°C/2h	EN 1600 E 19 9 H R 1 2 AWS/SFA 5.4 E308H-17	0.05	0.7	0.7	19.8	10		0.10		4

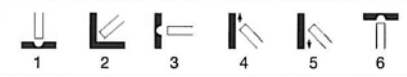
OK 61.50 is a stainless steel electrode for welding 19Cr 9 Ni austenitic stainless steels with a carbon content >0.04%. Especially designed for high temperature applications.

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.80		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Nb**	**FN**
Type of coating Acid Rutile **Recovery** 103% **Redrying** 350°C/2h	EN 1600 E 19 9 Nb R 1 2 AWS/SFA 5.4 E347-17 CE, GL, TÜV	0.03	0.7	0.6	19.5	10		0.09	0.29	7

OK 61.80 is a niobium-stabilised, stainless-steel, LMA electrode with a low carbon content for welding stainless types 321 and 347. It is resistant to intergranular corrosion up to 400°C.

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 61.81		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Nb**	**FN**
Type of coating Rutile **Recovery** 104 - 106% **Redrying** 350°C/2h	EN 1600 E 19 9 Nb R 3 2 AWS/SFA 5.4 E347-16 CE, DNV	0.06	0.7	1.7	20.2	9.7		0.08	0.72	5

Nb-stabilised MMA-electrode for welding Nb- or Ti-stabilised stainless steel of the 19Cr10Ni-type.



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
460	580	43	+20/100 -120/70 -196/50	2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	55 - 85 80 - 120 80 - 180 160 - 210 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
430	600	45	+20/60	2.5 x 300 3.2 x 350 4.0 x 350	50 - 85 70 - 110 110 - 165 DC+/AC/min. OCV: 55V	1 2 3 4 6 1 2 3 4 6 1 2

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
480	620	40	+20/60 -80/40	2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	55 - 90 70 - 130 90 - 180 140 - 250 DC+/AC/min. OCV: 50V	1 2 3 4 6 1 2 3 4 6 1 2 3 1 2

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
560	700	31	+20/60 -10/71	2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	40 - 60 50 - 80 75 - 115 80 - 160 140 - 210 DC+/AC/min. OCV: 60V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 6

Covered electrodes for MMA welding

OK 61.85

Type of coating
Basic

Recovery
100 - 107%

Redrying
200°C/2h

Classifications & approvals

EN 1600
E 19 9 Nb B 2 2
AWS/SFA 5.4
E347-15

Seproz, TÜV

Typical chemical composition all weld metal (%)

C	Si	Mn	Cr	Ni	Mo	N	Nb	FN
0.04	0.4	1.7	19.5	10.2		0.07	0.61	5

OK 61.85 is a basic coated, niobium stabilised electrode of the E347 type, specially designed for welding niobium or titanium stabilised steels. OK 61.85 has outstanding welding properties in the vertical and overhead positions, making it particularly suited for pipe welding.

OK 61.86

Type of coating
Acid Rutile

Recovery
98 - 101%

Redrying
350°C/2h

Classifications & approvals

EN 1600
E 19 9 Nb R 1 2
AWS/SFA 5.4
E347-17

Seproz

Typical chemical composition all weld metal (%)

C	Si	Mn	Cr	Ni	Mo	N	Nb	FN
<0.03	0.8	0.7	19.0	10.4		0.09	0.50	4

Low carbon, nßiobium stabilised stainless steel electrode for welding niobium or titanium stabilised steels of the 19Cr 10Ni-type. Specially designed for use in applications where heat treatment is required.

OK 62.53

Type of coating
Rutile

Recovery
100%

Redrying
300°C/2h

Classifications & approvals

Seproz

Typical chemical composition all weld metal (%)

C	Si	Mn	Cr	Ni	Mo	N	Other	FN
0.07	1.6	0.6	23.1	10.4	0.12	0.16		8

Niobium stabilised stainless steel electrode for welding niobium or titanium stabilised steels of the 19Cr 10Ni-type. Specially designed for use in applications where heat treatment is required.

OK 63.20

Type of coating
Acid Rutile

Recovery
100%

Redrying
350°C/2h

Classifications & approvals

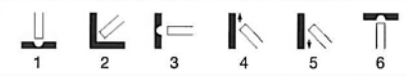
EN 1600
E 19 12 3 L R 1 1
AWS/SFA 5.4
E316L-16
CSA W48
E316L-16

CE, CWB, Seproz, TÜV

Typical chemical composition all weld metal (%)

C	Si	Mn	Cr	Ni	Mo	N	Nb	FN
0.02	0.7	0.7	18.4	11.5	2.8	0.11		4

Rutile coated electrode for welding 18Cr12Ni3Mo-type steels. Also suitable for welding stabilised steels of similar composition. The electrode is especially designed for welding thin walled pipes. Diameters 1.6-2.5mm. can be used in all positions including vertical down.



Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
500	620	40	+20/100 -60/70
600°C/16h: 500	640	40	+20/80 -60/40

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	55 - 85	1 2 3 4 6
3.2 x 350	75 - 110	1 2 3 4 6
4.0 x 350	80 - 150	1 2 3 4
5.0 x 350	150 - 200	1 2
	DC+	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
520	660	35	+20/55

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	60 - 90	1 2 3 4 6
3.2 x 350	70 - 120	1 2 3 4 6
4.0 x 350	120 - 170	1 2
	DC+/AC/min. OCV: 50V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
550	730	35	+20/60

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	50 - 90	1 2 3 4 6
3.2 x 350	70 - 110	1 2 3
4.0 x 350	85 - 150	1 2
	DC+/AC/min. OCV: 65V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
480	590	41	+20/56 -20/46

Diameter x length (mm x mm)	Current (A)	Welding positions
1.6 x 300	15 - 40	1 2 3 4 5 6
2.0 x 300	18 - 60	1 2 3 4 5 6
2.5 x 300	25 - 80	1 2 3 4 5 6
3.2 x 350	55 - 110	1 2 3 4 6
	DC+/AC/min. OCV: 50V	

Covered electrodes for MMA welding

OK 63.30	Classifications & approvals	Typical chemical composition all weld metal (%) C	Si	Mn	Cr	Ni	Mo	N	Other	FN
Type of coating Acid Rutile **Recovery** 102% **Redrying** 350°C/2h	EN 1600 E 19 12 3 L R 1 2 AWS/SFA 5.4 E316L-17 CSA W48 E316L-17 ABS, BV, CE, CWB, DB, DNV, GL, LR, Seproz, TÜV	0.02	0.8	0.6	18.1	11.0	2.7	0.10		6

Extra low carbon stainless steel electrode for welding steels of the 18Cr 12Ni 2.8Mo-type. Also suitable for welding of stabilised stainless steels of similar composition, exept when the full creep resistance of the base metal is to be met.

OK 63.34	Classifications & approvals	Typical chemical composition all weld metal (%) C	Si	Mn	Cr	Ni	Mo	N	Other	FN
Type of coating Acid Rutile **Recovery** 100% **Redrying** 350°C/2h	EN 1600 E 19 12 3 L R 1 1 AWS/SFA 5.4 E316L-16 CSA W48 E316L-16 CWB, Seproz, TÜV	0.02	0.8	0.8	18.7	11.8	2.8	0.13		6

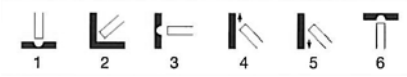
OK 63.34 is a stainless electrode of the 19Cr12Ni2.8Mo type, designed for the vertical-down welding of steels of similar composition. OK 63.34 produces beads with a very good finish and a smooth transition to the joint edges. The slag volume is fairly small and is easy to manipulate and easy to remove.

OK 63.35	Classifications & approvals	Typical chemical composition all weld metal (%) C	Si	Mn	Cr	Ni	Mo	N	Other	FN
Type of coating Basic **Recovery** 105% **Redrying** 200°C/2h	EN 1600 E 19 12 3 L B 2 2 AWS/SFA 5.4 E316L-15 CSA W48 E316L-15 ABS, CWB, Seproz, TÜV	0.04	0.4	1.6	18.3	12.6	2.7	0.06		4

Stainless steel electrode for welding steels of the CrNiMo 17-12-3 type. It can also be used for welding certain air hardening steels, e.g. armour steels. Very suitable for cryogenic applications. Requirement for lateral expansion 0.38mm at -196 C can be produced on request.

OK 63.41	Classifications & approvals	Typical chemical composition all weld metal (%) C	Si	Mn	Cr	Ni	Mo	N		FN
Type of coating Acid Rutile **Recovery** 150% **Redrying** 350°C/2h	EN 1600 E 19 12 3 L R 5 3 AWS/SFA 5.4 E316L-26 CE, DNV, LR, TÜV	0.03	0.8	0.7	18.2	12.5	2.8	0.09		4

High-efficiency low carbon stainless steel electrode for welding steels of the type 18 Cr 12 Ni 2-3 Mo.



Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
460	570	40	+20/60 -20/55 -60/43	1.6 x 300 2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	30 - 45 45 - 65 45 - 90 60 - 125 70 - 190 100 - 280 DC+/AC/min. OCV: 50V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
440	600	40	+20/65 -120/38	2.5 x 300 3.2 x 350	70 - 90 80 - 130 DC+/AC/min. OCV: 60V	1 2 3 4 5 6 1 2 3 4 5 6

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
430	560	40	+20/95 -60/75 -120/60 -196/35	2.5 x 300 3.2 x 350 4.0 x 350	55 - 85 80 - 120 80 – 180 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)	Diameter x length (mm x mm)	Current (A)	Welding positions
470	570	35	+20/60 -60/52	2.5 x 300 3.2 x 350 4.0 x 450 5.0 x 450	60 - 90 80 - 130 110 - 180 170 - 240 DC+/AC/min. OCV: 55V	1 2 3 4 6 1 2 3 1 2 3 1 2

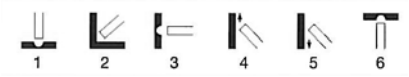
Covered electrodes for MMA welding

OK 63.80	Classifications & approvals	Typical chemical composition all weld metal (%)								
		C	Si	Mn	Cr	Ni	Mo	N	Nb	FN
Type of coating Acid Rutile	EN 1600: E 19 12 3 Nb R 3 2 AWS/SFA 5.4: E318-17	0.02	0.8	0.6	18.2	11.5	2.9	0.08	0.31	7
Recovery 110%	CE, Seproz, TÜV									
Redrying 350°C/2h	Acid rutile covered MMA-electrode for welding Nb or Ti stabilised steels of the CrNiMo 18-12-3 type.									

OK 63.85	Classifications & approvals	Typical chemical composition all weld metal (%)								
		C	Si	Mn	Cr	Ni	Mo	N	Nb	FN
Type of coating Basic	EN 1600 E 19 12 3 Nb B 4 2 AWS/SFA 5.4 E318-15	0.04	0.5	1.6	17.9	13.0	2.7	0.06	0.55	4
Recovery 115%	Seproz, TÜV									
Redrying 200°C/2h	Basic MMA-electrode for welding Nb-stabilised stainless steels of 18Cr 12Ni 3Mo-type.									

OK 64.30	Classifications & approvals	Typical chemical composition all weld metal (%)							
		C	Si	Mn	Cr	Ni	Mo	N	FN
Type of coating Acid Rutile	EN 1600: E 19 13 4 N L R 3 2 AWS/SFA 5.4: E317L-17	0.02	0.7	0.7	18.4	13.1	3.6	0.08	8
Recovery 103 - 110%	Seproz, TÜV								
Redrying 350°C/2h	OK 64.30 is an acid-rutile electrode for welding 19Cr 13Ni 3.5Mo (317L) austenitic stainless steels. The high Mo content provides better resistance to acid and pitting corrosion compared with 316L types. OK 64.30 is easy to weld in all positions and gives smooth runs on both AC and DC								

OK 64.63	Classifications & approvals	Typical chemical composition all weld metal (%)							
		C	Si	Mn	Cr	Ni	Mo	N	FN
Type of coating Acid Rutile	EN 1600: E 18 16 5 N L R 3 2	0.04	0.4	2.5	17.8	16.4	4.7	0.17	0
Recovery 114- 116%	TÜV								
Redrying 350°C/2h	OK 64.63 is a stainless electrode which deposits a fully austenitic (non-magnetic) weld metal of the CrNiMo type with very good corrosion resistance. It has excellent welding characteristics in all positions apart from vertical down.								



Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
507	614	38	+20/55 -60/41

Diameter x length (mm x mm)	Current (A)	Welding positions
2.0 x 300	45 - 65	1 2 3 4 6
2.5 x 300	60 - 90	1 2 3 4 6
3.2 x 350	80 - 120	1 2 3 4 6
4.0 x 350	120 - 170	1 2 3
	DC+/AC/min. OCV: 55V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
490	640	35	+20/65 -120/45

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	50 - 80	1 2 3 4 6
3.2 x 350	65 - 120	1 2 3 4 6
4.0 x 350	75 - 160	1 2 3 4 6
5.0 x 350	145 - 210	1 2 3
	DC+	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
480	600	30	+20/45

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	50 - 80	1 2 3 4 6
3.2 x 350	60 - 120	1 2 3 4 6
4.0 x 350	80 - 170	1 2 3 4 6
	DC+/AC/min. OCV: 55V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
480	640	35	+20/75

Diameter x length (mm x mm)	Current (A)	Welding positions
3.2 x 350	80 - 110	1 2 3 4 6
4.0 x 350	110 - 150	1 2 3
	DC+/AC/min. OCV: 60V	

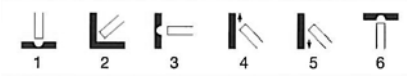
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.13		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic Rutile	EN 1600: E 25 20 R 1 2 AWS/SFA 5.4: E310-16	0.12	0.5	1.9	25.6	20.5			0
Recovery 95 - 100%									
Redrying 250°C/2h	OK 67.13 is an austenitic, stainless-steel electrode for welding 25Cr20Ni steels. The weld metal resists scaling up to a temperature of 1100-1150°C and does not contain any measureable ferrite. OK 67.13 can also be used for welding certain air-hardening steels such as armour plate and for welding stainless to unalloyed steel.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.15		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	EN 1600: E 25 20 B 2 2 AWS/SFA 5.4: E310-15	0.10	0.4	2.0	25.7	20.0			0
Recovery 100 - 105%	CE, DB, Seproz, TÜV								
Redrying 200°C/2h	Basic coated MMA-electrode for welding 25Cr 20Ni-steels. Also suitable for welding armour steels, austenitic manganese steels and for joining dissimilar steels.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.20		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 23 12 2 L R 1 1 AWS/SFA 5.4: (E309LMo-16)	0.02	1.1	0.8	22.9	13.1	2.9	0.13	15
Recovery 105%									
Redrying 250°C/2h	Austenitic stainless steel electrode producing a weld metal with less than 5% ferrite. The tough weld metal has excellent crack resistance, even when welding steels with very poor weldability. Suitable for joining 12-14% manganese steel to itself or other steels. Also suitable for depositing buffer layers before hardfacing.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.43		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Rutile Basic	EN 1600: E 18 8 Mn B 1 2 EN 14 700: EFe10 AWS/SFA 5.4: (E307-16)	0.08	0.8	5.4	18.4	9.1			0
Recovery 95 - 100%	CE, DB, Seproz, TÜV								
Redrying 350°C/2h	Austenitic stainless steel MMA-electrode giving a weld metal of the CrNiMn-type. The weld metal, which contains a small amount of uniformly distributed ferrite, is tough and has an excellent crack resistance. Suitable for joining 13%Mn type steels to other steels. Also suitable for welding other steels with very poor weldability.								



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
560	600	35	+20/60	2.5 x 300	50 - 85	1 2 3 4 6
				3.2 x 350	65 - 120	1 2 3 4 6
				4.0 x 350	70 - 160	1 2 3 4 6
				5.0 x 350	150 - 220	1 2 3
					DC+/AC/min. OCV: 65V	

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
410	590	35	+20/100	2.0 x 300	45 - 55	1 2 3 4 6
				2.5 x 300	50 - 85	1 2 3 4 6
				3.2 x 350	60 - 115	1 2 3 4 6
				4.0 x 350	70 - 160	1 2 3
				5.0 x 350	130 - 200	1 2 3
					DC+	

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
480	640	35	+20/60	2.0 x 300	30 - 60	1 2 3 4 5 6
				2.5 x 300	50 - 80	1 2 3 4 5 6
				3.2 x 350	75 - 110	1 2 3 4 6
					DC+/AC/min. OCV: 50V	

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
440	630	35	+20/80	2.5 x 300	60 - 80	1 2 3 4 6
				3.2 x 350	90 - 115	1 2 3 4 6
				4.0 x 350	100 - 150	1 2 3
				5.0 x 450	130 - 210	1 2 3
					DC+/AC/min. OCV: 65V	

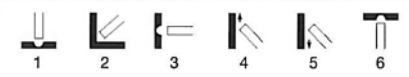
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.45		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Lime Basic	EN 1600: E 18 8 Mn B 4 2 AWS/SFA 5.4: (E307-15)	0.09	0.3	6.3	18.8	9.1			< 5
Recovery 100%	ABS, Seproz, TÜV								
Redrying 200°C/2h	Austenitic stainless steel electrode producing a weld metal with less than 5% ferrite. The tough weld metal has excellent crack resistance, even when welding steels with very poor weldability. Suitable for joining 12-14% Mn type steels to itself or other steels. Also suitable for depositing buffer layers before hardfacing.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.50		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 22 9 3 N L R 3 2 AWS/SFA 5.4: E2209-17 CSA W48:E2209-17	0.03	0.9	1.0	22.6	9.0	3.0	0.16	35
Recovery 103 - 108%	ABS, BV, CE, CWB, DNV, GL, RINA, Seproz, TÜV								
Redrying 350°C/2h	Acid rutile coated MMA electrode for welding of austenitic-ferritic stainless steels of CrNiMoN 22 5 3 and CrNiN 23 4-types.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.51		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 22 9 3 N L R 5 3 AWS/SFA 5.4: E2209-26	0.03	0.8	0.7	22.7	8.9	3.0	0.16	40
Recovery 142%	DNV								
Redrying 350°C/2h	High recovery stainless electrode for welding ferritic-austenitic (duplex) stainless steels, e.g. UNS S31803 or similar. Also excellent for joining duplex to CMn steels.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.52		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Zirconium Basic	EN 1600: E 18 8 Mn B 8 3 AWS/SFA 5.4: (E307-25) EN 14 700: E Fe10	0.09	0.9	7.0	17.7	8.5			< 3
Recovery 170 - 190%	Seproz								
Redrying 350°C/2h	Synthetic high efficiency stainless steel electrode of the 18Cr8Ni6Mn-type for repair welding and joining 13% Mn-steel, welding steels of reduced weldability, cladding carbon steels etc.								



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
470	605	35	+20/85	2.5 x 300	50 - 80	1 2 3 4 6
				3.2 x 350	70 - 100	1 2 3 4 6
				4.0 x 350	80 - 140	1 2 3 4 6
				5.0 x 450	150 - 200	1 2 3
					DC+	

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
690	857	25	+20/50	2.0 x 300	30 - 65	1 2 3 4 6
			-30/41	2.5 x 300	50 - 90	1 2 3 4 6
				3.2 x 350	80 - 120	1 2 3 4 6
				4.0 x 350	90 - 160	1 2 3 4
				5.0 x 350	150 - 220	1 2
					DC+/AC/min. OCV: 60V	

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
645	800	25	+20/50	2.5 x 300	60 - 100	1 2 3 4 6
				3.2 x 350	80 - 130	1 2
					DC+/AC/min. OCV: 60V	

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
420	630	45	+20/70	2.5 x 350	90 - 115	1 2 3 4 6
				3.2 x 450	120 - 165	1 2
				4.0 x 450	150 - 240	1 2
				5.0 x 450	200 - 340	1
					DC+/AC/min. OCV: 70V	

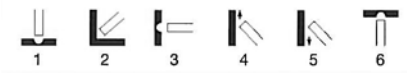
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.53		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Rutile	EN 1600: E 22 9 3 N L R 1 2 AWS/SFA 5.4: (E2209-16)	0.03	1.0	0.7	23.7	9.3	3.4	0.16	35
Recovery 97 - 105%	DNV, TÜV								
Redrying 350°C/2h	OK 67.53 is a rutile coated electrode designed for welding ferritic-austenitic duplex stainless steel pipes, e g UNS 31803 and 1.4462. The electrode has a thin coating which is ideal for root runs and positional welding.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.55		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	EN 1600: E 22 9 3 N L B 2 2 AWS/SFA 5.4: E2209-15	0.03	0.7	1.0	23.2	9.4	3.2	0.17	40
Recovery 102 - 106%	DNV, Seproz, TÜV								
Redrying 200°C/2h	OK 67.55 is a basic coated electrode specially designed for the welding of duplex stainless steel, e.g. UNS S31803. The deposited weld metal gives very high ductility down to -50°C/-60°C. Particularly suitable for welding duplex pipes in off-shore applications.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.60		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 23 12 L R 3 2 AWS/SFA 5.4: E309L-17 CSA W48: E309L-17	0.03	0.8	0.9	23.7	12.4		0.09	15
Recovery 115%	CE, CWB, Seproz, TÜV								
Redrying 350°C/2h	Acid-rutile coated MMA electrode giving an over-alloyed weld metal. Suitable for welding stainless steel to mild and low alloyed steels. Also suitable for welding transition layers when surfacing mild steel with stainless steel weld metal.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.62		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Rutile	EN 1600: E Z 23 12 L R 7 3 AWS/SFA 5.4: E309-26	0.04	0.8	0.6	23.7	12.7		0.09	15
Recovery 170 - 175%	BV, DNV, GL, LR, Seproz, TÜV								
Redrying 350°C/2h	OK 67.62 is a synthetic, stainless, high recovery electrode of the 24Cr12Ni type for welding stainless steel to unalloyed steel. The composition is balanced to produce good crack resistance when welding stainless steel to mild steel. The bead appearance is outstanding in both butt welds and fillet welds.								



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
660	840	25	+20/56	2.0 x 300 2.5 x 300 3.2 x 350	25 - 60 30 - 80 70 - 110 DC+/AC/min. OCV: 55V	1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
650	800	28	+20/100 -20/85 -60/65	2.5 x 300 3.2 x 350 4.0 x 350	50 - 80 60 - 100 80 - 140 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
470	580	32	+20/50 -10/40	2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	45 - 65 45 - 90 65 - 120 85 - 180 110 - 250 DC+/AC/min. OCV: 55V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
440	560	36	+20/60 -60/42	3.2 x 450 4.0 x 450 5.0 x 450	110 - 165 150 - 230 200 - 310 DC+/AC/min. OCV: 55V	1 2 3 1 2 3 1 2 3

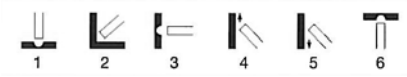
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.70		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 23 12 2 L R 3 2 AWS/SFA 5.4: E309LMo-17 CSA W48: E309LMo-17	0.02	0.8	0.6	22.5	13.4	2.8	0.08	18
Recovery 106 - 110%	ABS, BV, CE, CWB, DNV, LR, RINA, Seproz, TÜV								
Redrying 350°C/2h	Acid rutile MMA electrode giving an over-alloyed weld metal. Suitable for welding acid resistant stainless steels to mild and low-alloyed steels. Also suitable for welding buffer layers when surfacing mild steel with acid resistant stainless steel weld metal.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.71		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 23 12 2 L R 5 3 AWS/SFA 5.4: E309LMo-26	0.04	0.9	0.9	22.9	13.3	2.6	0.08	15
Recovery 150%	DNV, TÜV								
Redrying 350°C/2h	OK 67.71 is an over-alloyed, high recovery electrode for welding transition layers when surfacing mild steel with stainless and joining stainless steel to other types of steel. The ferritic-austenitic weld metal is very crack resistant.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 67.75		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	EN 1600: E 23 12 L B 4 2 AWS/SFA 5.4: E309L-15	0.04	0.3	0.2	23.5	12.9		0.06	15
Recovery 120%	ABS, DNV, LR, Seproz, TÜV								
Redrying 200°C/2h	OK 67.75 is a basic coated, stainless electrode for welding steels of the 24Cr13Ni type, for welding buffer layers when surfacing mild steel with stainless, for joining dissimilar steels and welding root runs in the stainless side of clad steels.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.15		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Lime Basic	EN 1600: E 13 B 4 2 EN14 700: E Fe7 AWS/SFA 5.4: E410-15	0.04	0.4	0.3	12.9				
Recovery 108-118%	Seproz								
Redrying 200°C/2h	OK 68.15 is a stainless steel electrode which deposits a ferritic 13Cr weld metal. OK 68.15 is designed for welding steels of similar composition, when CrNi-alloyed austenitic stainless steel electrodes cannot be used, e.g. when exposed to aggressive sulphuric gases. Depending on the welding parameters, the structure and consequently the mechanical properties of untreated weld metal can vary within relatively large limits.								



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
510	610	32	+20/50 -20/35	2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	40 - 60 50 - 90 60 - 120 85 - 180 110 - 250 DC+/AC/min. OCV: 55V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
500	620	35	+20/55 -60/30	3.2 x 350 4.0 x 450 5.0 x 450	60 - 130 110 - 170 170 - 230 DC+/AC/min. OCV: 70V	1 2 3 1 2 3 1 2 3

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
470	600	35	+20/75 -80/55	2.5 x 300 3.2 x 350 4.0 x 350	50 - 80 80 - 110 80 - 150 DC+	1 2 3 1 2 3 1 2 3

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
370 (PWHT: 750°C/1h)	520	25		2.5 x 350 3.2 x 450 4.0 x 450	65 - 115 90 - 160 120 - 220 DC+	1 2 3 4 6 1 2 3 1 2

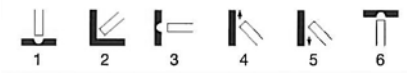
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.17		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Rutile Basic	EN 1600: E 13 4 R 3 2 EN 14 700: E Fe7 AWS/SFA 5.4: E410NiMo-16	0.02	0.4	0.6	12.0	4.6	0.6		
Recovery 115 -118%	Seproz								
Redrying 350°C/2h	A rutile-basic electrode for welding martensitic 13Cr4Ni-Mo type steels								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.25		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	EN 1600: E 13 4 B 4 2 EN 14 700: E Fe7 AWS/SFA 5.4: E410NiMo-15	0.04	0.4	0.6	12.2	4.5	0.6		
Recovery 117 -121%	Seproz								
Redrying 350°C/2h	Basic coated electrode for welding corrrosion resistant martensitic and martensitic-ferritic rolled, forged and cast steels, for example castings of 13Cr4NiMo-type.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.37		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	NF A 81-383: E Z 17.4.1.B 20	0.05	0.16	1.1	16.0	5.0	0.43		
Recovery 120%	Basic coated electrode for joining and repairing of corrosion resistant martensitic rolled, forged and cast steels, for example hydro turbine runners of the 17Cr4Ni type.								
Redrying 250°C/2h									

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.53		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic Rutile	EN 1600: E 25 9 4 N L R 3 2 AWS/SFA 5.4: E2594-16	0.03	0.6	0.7	25.2	10.3	4.0	0.25	39
Recovery 106%	DNV, Seproz, TÜV								
Redrying 250°C/2h	OK 68.53 is a coated electrode for welding austenitic-ferritic steels of super duplex types, e.g. SAF 2507 and Zeron 100. It has good welding characteristics in all positions and the slag is easily detachable.								



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
650 (PWHT: 600˚C/2h + 600˚C/8h)	870	17	+20/45 -10/45 -40/40	2.5 x 350 3.2 x 350 4.0 x 450	55 - 100 65 - 135 90 - 190 DC+/AC/min. OCV: 55V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
680 (PWHT: 600˚C/8h)	900	17	+20/65 0/60 -20/55	3.2 x 450 4.0 x 450 5.0 x 450	90 - 150 110 - 190 140 - 250 DC+	1 2 3 4 6 1 2 3 4 6 1 2

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
710 (PWHT: 600˚C/3h)	950	14		2.5 x 350 3.2 x 450 4.0 x 450	55 - 80 100 - 120 135 - 170 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
700	850	30	-40/40	2.5 x 300 3.2 x 350 4.0 x 350	55 - 85 70 - 110 80 - 150 DC+/AC/min. OCV: 60V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

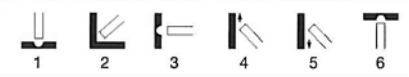
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.55		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	EN 1600: E 25 9 4 N L B 4 2 AWS/SFA 5.4: E2594-15	0.03	0.6	0.9	25.2	10.4	4.3	0.24	45
Recovery 107 - 109%	DNV								
Redrying 250°C/2h	OK 68.55 is a basic coated electrode for welding austenitc-ferritic steels of the super duplex type, e. g. SAF 2507 and Zeron 100. OK 68.55 deposits a weld metal with high ductility.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.81		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 29 9 R 3 2 EN 14 700: E Fe11 AWS/SFA 5.4: E312-17	0.13	0.7	0.9	28.9	10.2			50
Recovery 125%	Seproz								
Redrying 350°C/2h	High recovery, high alloy stainless electrode of unusual versatility, giving a ferritic-austenitic duplex weld metal with an approximate ferrite content of FN 50. The weld metal is resistant to stress corrosion attack and highly insensitive to dilution from the parent metal. Good scaling resistance up to 1150 °C. Typical applications: joining of HWT steels, dissimilar steels, surfacing rails, rolls, alforging dies, hot work tools, dies for plastics etc.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 68.82		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Acid Rutile	EN 1600: E 29 9 R 3 2 EN 14 700: E Fe11 AWS/SFA 5.4: (E312-17)	0.13	1.1	0.6	29.1	9.9			50
Recovery 105%	Seproz								
Redrying 300°C/2h	High alloy stainless electrode of unusual versatility, giving a ferritic-austenitic duplex weld metal with an approximate ferrite content of FN 50. The weld metal is resistant to stress, corrosion attack and highly insensitive to dilution from the parent metal. Good scaling resistance up to 1150 °C. Applications: joining of HWT steels, dissimilar steels, welding steels of poor weldability eg spring steels, surfacing rails, rolls forging die hot work tools, die for plastics, etc.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 69.25		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
Type of coating Basic	EN 1600: E 20 16 3 Mn N L B 4 2 AWS/SFA 5.4: E316LMn-15	0.04	0.5	6.5	19.0	16.0	3.0	0.15	< 0.5
Recovery 115 - 117%	Basic coated stainless electrode for welding corrosion resistant, non-magnetic and cryogenic stainless steels. The electrode gives a fully austenitic Cr-Ni-Mo weld metal with increased Mn- and N-content.								
Redrying 200°C/2h									



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
700	900	28	+20/90 -40/55 -60/45	2.5 x 300 3.2 x 350 4.0 x 350	50 - 80 60 - 100 100 - 140 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
610	790	22	+20/30	2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	40 - 60 50 - 85 60 - 125 80 - 175 150 - 240 DC+/AC/min. OCV: 60V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 1 2

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
500	750	23	+20/40	2.0 x 300 2.5 x 300 3.2 x 350 4.0 x 350 5.0 x 350	40 - 60 50 - 85 55 - 120 75 - 170 140 - 230 DC+/AC/min. OCV: 55V	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6 1 2 3 1 2

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
450	650	35	+20/90 -196/50	2.5 x 300 3.2 x 350 4.0 x 350	50 - 80 70 - 100 100 - 140 DC+	1 2 3 4 6 1 2 3 4 6 1 2 3 4 6

Covered electrodes for MMA welding

OK 69.33

Type of coating
Basic-Rutile

Recovery
110 - 120%

Redrying
250°C/2h

Classifications & approvals	Typical chemical composition all weld metal (%)								
	C	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Cu**	**FN**
EN 1600: E 20 25 5 Cu N L R 3 2 AWS/SFA 5.4: E385-16	0.03	0.5	1.0	20.5	25.5	4.8	0.08	1.7	0

OK 69.33 is a stainless steel electrode which deposits a fully austenitic weld metal with increased resistance to sulphuric acid. The weld metal of OK 69.33 also has good resistance to intergranular and pitting corrosion.

OK 310Mo-L

Type of coating
Acid Rutile

Recovery
100%

Redrying
200°C/2h

Classifications & approvals	Typical chemical composition all weld metal (%)							
	C	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**
EN 1600: E 25 22 2 N L R 1 2 AWS/SFA 5.4: (E310Mo-16)	0.038	0.4	4.4	24.2	21.7	2.4	0.14	0

Rutile-basic electrode for the joining and cladding of steel containing 25% Cr 22% Ni 2% Mo N.
The weld metal has an excellent resistance to very agressive corrosive media, such as in urea plants.
The fully austenitic weld metal is insensitive to hot cracking. OK 310Mo-L is approved for the construction and repair of urea plants using the stamicarbon process. The electrode is regularly used for routine repair works on AISI 316L in urea plants to gain superior resistance to corrosive attack.

OK 92.05

Type of coating
Lime Basic

Recovery
90%

Redrying
250°C/2h

Classifications & approvals	Typical chemical composition all weld metal (%)							
	C	**Si**	**Mn**	**Cr**	**Ni**	**Ti**	**Al**	**Fe**
EN ISO 14 172: E Ni 2061 (NiTi3) AWS/SFA 5.11: ENi-1	0.04	0.7	0.4		96	1.5	0.10	0.4

A stick electrode for joining commercially pure nickel in wrought and cast forms. Also for joining dissimilar metals such as nickel to steel, nickel to copper and copper to steel. The electrode can also be used for surfacing steel.

OK 92.15

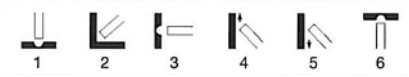
Type of coating
Basic

Recovery
110%

Redrying
250°C/2h

Classifications & approvals	Typical chemical composition all weld metal (%)							
	C	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Nb**	**Fe**
EN ISO 14 172: E Ni 6133 (NiCr16Fe12NbMo) AWS/SFA 5.11: ENiCrFe-2 ABS, Seproz	0.03	0.45	2.7	16.1	69	1.9	1.9	7.7

Nickel based electrode for welding Inconel 600 and similar alloys, cryogenic steels (e.g. 9% and 5% Ni steel), martensitic to austenitic steels, dissimilar steels, heat resisting steel castings of limited weldability etc. Good weldability in all positions, including overhead.



Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
400	575	35	+20/80 -140/45

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	60 - 85	1 2 3 4 6
3.2 x 350	85 - 130	1 2 3 4
4.0 x 350	95 - 180	1 2
5.0 x 350	160 - 240	1 2
	DC+/AC/min. OCV: 65V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
442	623	34	+20/54

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	55 - 70	1 2 3 4 6
3.2 x 300	70 - 100	1 2 3 4 6
4.0 x 300	100-140	1 2 3 4
	DC+	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
330	470	30	

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	70 - 95	1 2 3 4 6
3.2 x 350	90 - 135	1 2 3 4 6
	DC+	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
420	660	45	+20/110 -196/90

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	50 - 80	1 2 3 4 6
3.2 x 350	70 - 105	1 2 3 4 6
4.0 x 350	95 - 140	1 2 3 4 6
	DC+	

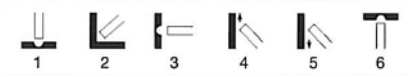
Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 92.18		**C**	**Si**	**Mn**	**Ni**	**Fe**			
Type of coating Basic Special	EN ISO 1071: E C Ni-CI 3 AWS/SFA 5.15: ENi-CI	1.0	0.6	0.8	94	4			
Recovery 105 - 107%	Seproz								
Redrying 200°C/2h	A nickel-cored electrode for joining normal grades of cast iron, such as grey, ductile and malleable irons. It is also suitable for the rectification and repair of these grades and for joining them to steel. Deposition is done on cold or slightly preheated cast iron. Weld metal is well machinable.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 92.26		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Nb**	**Fe**	
Type of coating Basic	EN ISO 14 172: E Ni 6182 (NiCr15Fe6Mn) AWS/SFA 5.11: ENiCrFe-3	0.03	0.5	6.6	15.8	66.9	1.7	8.8	
Recovery 110%	ABS, Seproz								
Redrying 200°C/2h	Basic nickel-based electrode for welding Inconel 600 and similar Inconel alloys, cryogenic steels, martensitic to austenitic steels, dissimilar steels, heat resisting steel castings of limited weldability.								

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 92.35		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**W**	**Fe**
Type of coating Rutile basic	EN 14 700: E Z Ni2 AWS/SFA 5.11: (ENiCrMo-5)	0.05	0.5	0.9	15.5	57.5	16.4	3.5	5.5
Recovery 185-190%	Nickel-based electrode for welding Inconel 600 and similar Inconel alloys, cryogenic steels, martensitic to austenitic steels, dissimilar steels, heat resisting steel castings of limited weldability.								
Redrying 350°C/2h									

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 92.45		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Nb**	**Fe**
Type of coating Basic	EN ISO 14 172: E Ni 6625 (NiCr22 Mo9Nb AWS/SFA 5.11: ENiCrMo-3	0.03	0.4	0.2	21.7	63	9.3	3.3	2.0
Recovery 94 - 105%	Seproz, TÜV								
Redrying 200°C/2h	OK 92.45 is a NiCrMoNb-based electrode for welding nickel alloys of the same or similar type, like Inconel 625, and for welding 5Ni and 9Ni steel. OK 92.45 is also suitable for welding UNS S31254 steel.								



Typical mechanical properties all weld metal

$R_{p\ 0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
	300		

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	55 - 110	1 2 3 4 6
3.2 x 350	80 - 140	1 2 3 4 6
4.0 x 350	100 - 190	1 2 3
	AC/DC+/min. OCV: 50V	

Typical mechanical properties all weld metal

$R_{p\ 0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
410	640	40	+20/100 -196/80

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	50 - 70	1 2 3 4 6
3.2 x 350	65 - 105	1 2 3 4 6
4.0 x 350	75 - 150	1 2 3 4 6
5.0 x 350	120 - 170	1 2 3
	DC+	

Typical mechanical properties all weld metal

$R_{p\ 0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
515	750	17	

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	65 - 110	1 2
3.2 x 350	110 - 150	1 2
4.0 x 350	160 - 200	1 2
5.0 x 350	190 - 250	1 2
	DC+/AC/min. OCV: 70V	

Typical mechanical properties all weld metal

$R_{p\ 0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
500	780	35	+20/70 -196/50

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 350	55-75	1 2 3 4 6
3.2 x 350	65-100	1 2 3 4 6
4.0 x 350	80-140	1 2 3 4 6
5.0 x 350	120-170	1 2 3 4
	DC+	

Covered electrodes for MMA welding

OK 92.55

Type of coating
Basic

Recovery
136%

Redrying
300°C/1-2h

Classifications & approvals

EN ISO 14 172: E Ni 6620 (NiCr14Mo7Fe)
AWS/SFA 5.11: ENiCrMo-6

ABS, BV, DNV

Typical chemical composition all weld metal (%)

C	Si	Mn	Cr	Ni	Mo	W	Nb	Fe
0.05	0.3	3.0	12.9	69.4	6.2	1.6	1.3	5.0

OK 92.55 is an all-positional, basic coated electrode which deposits a NiCr-based alloy with additions of Mo, W and Nb. The electrode is specifically designed for welding 9%Ni steels for cryogenic applications down to -196°C.

OK 92.58

Type of coating
Basic Special

Recovery
105%

Redrying
200°C/2h

Classifications & approvals

EN ISO 1071: E C NiFe-CI-A 1
AWS/SFA 5.15: ENiFe-CI-A

Seproz

Typical chemical composition all weld metal (%)

C	Si	Mn	Ni	Al	Fe
1.5	0.7	0.8	51	1.4	46

A nickel-iron cored electrode for joining normal grades of cast iron, such as grey, ductile and malleable irons. It is also suitable for the rectification and repair of these grades and for joining them to steel. Deposition is done on cold or slightly preheated cast iron. Weld metal is well machinable. The electrode produces a weld metal stronger and more resistant to solidification cracking than that of the nickel electrode type, also used for welding of cast iron. Because of this, it is specially used for high duty welds in ductile irons and for welding grey irons with increased contents of sulphur and phosphorous.

OK 92.59

Type of coating
Basic

Recovery
100%

Redrying
200°C/2h

Classifications & approvals

EN ISO 14 172: E Ni 6059 (NiCr23Mo16)
AWS/SFA 5.11: ENiCrMo-13

Typical chemical composition all weld metal (%)

C	Si	Mn	Cr	Ni	Mo	W	Fe
0.01	0.2	0.2	22	61	15.2	0.25	0.8

OK 92.59 is designed for welding of Alloy 59, C-276 and 625 Ni-base materials. Also for welding superaustenitic steels type AISI/ASTM S31254 and S32654.

OK 92.60

Type of coating
Basic Special

Recovery
110%

Redrying
200°C/2h

Classifications & approvals

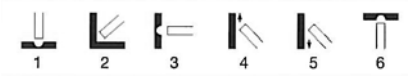
EN ISO 1071: E C NiFe-1 3
AWS/SFA 5.15: ENiFe-CI

Seproz

Typical chemical composition all weld metal (%)

C	Si	Mn	Ni	Fe	Cu	Al
0.9	0.5	0.6	53	4.4	0.9	0.4

A nickel-iron electrode for welding normal grades of cast iron and for joining these to steel. A special iron jacketed Ni-core wire gives the electrode a good current carrying capacity. The weld metal is stronger and more resistant to solidification cracking than pure nickel electrode types.



Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
	>690	>35	-196/>70

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 350	65-115	1 2 3 4 6
3.2 x 350	70-150	1 2 3 4 6
4.0 x 350	120-200	1 2 3
5.0 x 350	150-240	1 2 3
	DC+/AC/min. OCV: 55V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4 (%)	CVN (°C/J)
	375		

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	55 - 75	1 2 3 4 5 6
3.2 x 350	70 - 100	1 2 3 4 5 6
4.0 x 350	85 - 160	1 2 3
	DC+/AC/min. OCV: 50V	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
430	770	40	-60/70 -196/60

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	50 - 70	1 2 3 4 6
3.2 x 350	60 - 90	1 2 3 4 6
4.0 x 350	80 -120	1 2 3 4 6
	DC+	

Typical mechanical properties all weld metal

$R_{p\,0.2}$ (MPa)	Rm (MPa)	A5 (%)	CVN (°C/J)
380	560	>15	

Diameter x length (mm x mm)	Current (A)	Welding positions
2.5 x 300	60 - 100	1 2 3 4 5 6
3.2 x 350	80 - 150	1 2 3 4 5 6
4.0 x 350	100 -200	1 2 3
5.0 x 350	150 - 250	1 2 3
	DC+/AC/min. OCV: 45V	

Covered electrodes for MMA welding

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 92.78		**C**	**Mn**	**Ni**	**Cu**	**Fe**				
Type of coating Basic Special	EN ISO 1071: E C NiCu 1	0.35	0.9	65	32	2.2				
Recovery 95%	A nickel-copper cored electrode of monel type for welding normal grades of cast iron such as grey, ductile and malleable irons. Deposition is done on cold or slightly preheated material. The weld metal is well machinable and the colour is very similar to that of cast iron.									
Redrying 80°C/2h										

	Classifications & approvals	Typical chemical composition all weld metal (%)								
OK 92.86		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Fe**	**Ti**
Type of coating Basic	EN ISO 14 172: E Ni 4060 (NiCu30Mn3Ti) AWS/SFA 5.11:ENiCu7	0.01	0.3	2.1		66		29	1.6	0.2
Recovery 105%	Seproz									
Redrying 200°C/2h	A nickel-copper electrode for welding NiCu alloys to themselves and to steels and for corrosion-resistant surfacing. The weld metal of OK 92.86 is crack resistant and ductile and meets rigorous requirements relating to corrosion resistance in sea water and in reducing and oxidising acids. OK 92.86 is used for welding corrosion-resistant Monel alloys within the petroleum and ammonium sulphate industry and in power plants.									

	Classifications & approvals	Typical chemical composition all weld metal (%)							
OK 94.25		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Sn**
Type of coating Basic	DIN 1733: EL-CuSn7			0.35				93	6.5
Recovery 95%	Seproz								
Redrying 300°C/2h	Electrode for welding copper and bronzes, especially tin bronzes. It is also suited for cladding steels and for smaller repair work on weldable cast iron.								

ESAB MMA electrodes for positional welding of thin stainless pipe and sheet

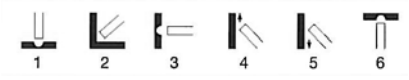
ESAB introduces three new rutile MMA electrodes with excellent all-positions arc control at very low welding currents - OK 61.20, OK 63.20 and OK 67.53.

They have been developed in co-operation with the petrochemical and paper and pulp industry - in response to the increasing use of thin-walled stainless pipe and sheet to extend the lifecycle of installations. They are also applied in the petrochemical, energy and food processing industries.

Stable arc at low currents

A stable, soft arc at very low current and voltage makes them suitable for both up-

- **Productive welding**
- **Reduced post weld cleaning**
- **Good corrosion resistance in demanding environments**



Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
	325	15		2.5 x 300 3.2 x 350 4.0 x 350	50 - 100 60 - 125 90 -140 DC+/AC/min. OCV: 45V	1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A4 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
410	640	40	+20/100 -196/80	2.5 x 300 3.2 x 350 4.0 x 350	50 - 70 70 - 120 120-140 DC+/AC/min. OCV: 70V	1 2 3 4 6 1 2 3 4 6 1 2 3

Typical mechanical properties all weld metal				Diameter x length	Current	Welding positions
$R_{p\,0.2}$ (MPa)	**Rm (MPa)**	**A5 (%)**	**CVN (°C/J)**	**(mm x mm)**	**(A)**	
235	360	25	+20/25	2.5 x 350 3.2 x 350 4.0 x 350	60 - 90 90 - 125 125-170 DC+	1 2 3 4 1 2 3 4 1 2 3 4

and downhill welding of pipes with a wall thickness in the region of 2 mm. The slag system allows a long pull-out length, reducing electrode change time loss.

Low spatter, good slag release and good wetting minimise time loss in post-weld cleaning. Corrosion resistance meets the requirements of demanding environments found in, for example, the petrochemical and shipbuilding industries.

OK 61.20 used for the vertical down welding of water supply piping in the pipeshop at a paper and pulp plant (AISI 304, 2.5 mm wall thickness). The remote control on the CaddyArc portable inverter is used to prevent burn-through by controlling the arc which is directed at the root of the joint. Welding is carried out in the two o'clock position while the pipe is rotated upwards, manually.

Solid wires for MIG Welding

Welding Data

MIG welding can be performed with three techniques; short arc (dip transfer), spray arc and pulsed welding. Short arc welding is used for thin materials, for root runs in thicker materials and for positional welding.

Short arc welds are made with lower voltage and current settings than spray arc welds. Metal is transferred across a short arc to the molten pool by short-circuiting droplets.

In spray arc welding, metal transfer occurs as a fine spray of droplets, which do not short-circuit the arc. This technique is more productive and is best suited for downhand welding of material with thickness of 3 mm and upward.

In pulsed arc welding, the metal transfer is controlled by a suitable voltage pulse, which is super-imposed onto the constant base voltage. This creates an artificial spray arc with one drop of metal per pulse within the normal short arc range. The average current is significantly lower than in ordinary spray arc welding; an obvious benefit when welding many types of stainless steels. Pulsed arc welding can be used in all positions and controls the heat input.

Shielding gas

In addition to general shielding of the arc and weld pool, the shielding gas performs a number of important functions:

- forms the arc plasma
- stabilises the arc root on the material surface
- ensures smooth transfer of molten droplets from the wire to the weld pool

Thus, the shielding gas will have a substantial effect on the stability of the arc and metal transfer and the behaviour of the weld pool, in particular, its penetration. General purpose shielding gases for MIG welding are mixtures of argon, oxygen and carbon dioxide, and special gas mixtures may contain helium. The gases, which are normally used for stainless, are:

- argon + 1 - 2% oxygen
- argon + 2 - 3% carbon dioxide
- argon + helium + carbon dioxide + hydrogen

An inert gas alone, argon or an argon + helium mixture is only recommended for welding high nickel-alloyed steels and nickel-based alloys.

When MIG welding stainless steel, the arc is very unstable with inert gas alone. A small quantity of oxygen or carbon dioxide in the argon shield improves the arc stability as well as the fluidity and wetting of the weld metal. The addition also minimises undercut, which is a problem when welding with argon alone.

In the case of welding ELC steels (steels with a maximum of 0.03 % carbon) an increase in the carbon content is not permitted. Generally, argon with up to 5% CO_2 behaves in a neutral manner, but a possible increase in carbon content when welding ELC steels should be taken into account. Argon with 2% carbon dioxide adds about 0.01% carbon to the weld metal when welding with spray arc transfer.
A four gas mixture can offer advantages in

Current and voltage recommendations.

Diam, mm	Arc voltage, V	Current, A
0.8	16-22	50-140
1.0	16-24	80-190
1.2	20-28	180-280
1.6	24-28	250-350

short arc welding. Helium in the gas mixture can give better shielding in positional welding and also improves penetration. However, hydrogen in the shielding gas must be avoided when welding a non austenitic stainless steel.

Delivery forms

Most OK Autrod wires are available on standard spools, No. 98-0 (EN 759: BS 300) with an outer diameter of 300 mm. Net weight of the spool is 15 kg. The wire is precision wound and the spool is used without adapter. Some grades in smaller diameters are also available in 5 kg spools, No. 46 (EN 759: S200), a plastic spool with an outer diameter of 200 mm.

The majority of wires are also available in ESAB bulk wire system, Marathon Pac™. This package promotes lean manufacturing through reduced downtime, process stability and efficient consumables handling. It saves on handling time and spool disposal costs. Marathon Pac has built in lifting straps and a range of accessories that simplify on-site handling from goods-in to workstation. Once empty, the octagonal drum packs flat to save space and ease disposal. The Pac is also 100% recyclable. The table on this page reviews the complete Marathon Pac family.

Marathon Pac can also be delivered in Endless Pac, this is two standard, or two Jumbo Pacs, joined together. Before the Marathon Pac finishes, the wire from a second Pac is joined to the first, using a special butt welding device. The clever changeover mechanism then automatically transfers the feed from the first drum into the second drum while the robot continues to weld faultlessly.

Wire diameters available are 0.8, 0.9, 1.0, 1.2 and 1.6 mm.

Matt wire

The most common grades are produced with a matt wire surface, due to a special manufacturing process. This technique produce wires that give a better welding quality, greater arc stability and higher production output. Because the manufacturing process produces a wire with improved stiffness, a more constant current flow without voltage fluctuations is obtained. The matt surface is finished with a special feed-aid that does not accumulate within the feeding system or welding gun.

ESAB matt stainless steel MIG wire

The Marathon Pac family

Description	Weight	W x H
Mini Marathon Pac	100 kg,	513 x 500 mm
Standard Marathon Pac	250 kg,	513 x 830 mm
Jumbo Marathon Pac	475 kg,	595 x 935 mm

Solid wires for MIG/MAG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 308H		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 19 9 H AWS/SFA A5.9 ER308H	0.04	0.4	1.8	19.5	9			Tot <0.5	5-10	Min 350	Min 550	Min 30	

A continuous, solid, corrosion resistant, chromium-nickel wire for welding austenitic chromium-nickel alloys of the 18% Cr-8% Ni type. OK Autrod 308H has good general corrosion resistance. The alloy has a high carbon content, making it suitable for applications used at higher temperatures. The alloy is used in chemical and petrochemical plants for the welding of pipes, cyclones and boilers.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 308L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 19 9 L AWS/SFA 5.9 ER308L	0.02 **Cu** 0.05	0.4	1.6	20	10	0.05	<0.08	Tot <0.5	5-10	450	620	36	-20/110 -60/90 -196/60

A continuous solid corrosion resistant chromium-nickel wire. OK Autrod 308L has a good general corrosion resistance. The alloy has a low carbon content which makes this alloy particularly recommended when there is a risk of intergranular corrosion. The alloy is widely used in the chemical and food processing industries as well as for pipes, tubes and boilers. For joining of stainless steels of 18% Cr - 8% Ni-type and Nb-stabilised steels of the same type if the service temperature will not exceed 350°C.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 308LSi		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 19 9 LSi AWS/SFA A5.9 ER308LSi	0.01	0.8	1.8	20	10	0.1	<0.08	Tot <0.5	8	370	620	36	+20/110 -60/90 -196/60
	CE, DB, DNV, TÜV													

A continuous, solid, corrosion resistant, chromium-nickel wire for welding austenitic chromium-nickel alloys of the 18 Cr-8% Ni type. OK Autrod 308LSi has good general corrosion resistance. The alloy has a low carbon content, making it particularly recommended when there is a risk of intergranular corrosion. The higher silicon content improves the welding properties such as wetting. The alloy is widely used in the chemical and food processing industries, as well as for pipes, tubes and boilers.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 309L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 23 12 L AWS/SFA 5.9 ER309L	0.03	0.4	1.5	23.5	13	0.1	<0.11	Tot <0.5	9	440	600	41	+20/160 -60/130 -110/90
	CE													

A continuous solid corrosion resistant chromium-nickel wire for welding similar steels, wrought and cast steels of 23% Cr-12% Ni types. The alloy is also used for the welding of buffer layers on CMn steels and the welding of dissimilar joints. When using the wire for buffer layers and dissimilar joints, it is necessary to control the dilution of the weld. OK Autrod 309L has a good general corrosion resistance. When used for joining dissimilar materials, the corrosion resistance is of secondary importance.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 309LSi		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 23 12 LSi AWS/SFA 5.9 ER309LSi	0.02	0.8	1.8	24	13	0.1	<0.09	Tot <0.5	8	440	600	41	+20/160 -60/130 -110/90
	DB, CE, TÜV													

A continuous, solid, corrosion resistant, chromium-nickel wire for welding steels with a similar composition, wrought and cast steels of the 23% Cr -12% Ni types. The alloy is also used for welding buffer layers on CMn steels and welding dissimilar joints. When using the wire for buffer layers and dissimilar joints, it is necessary to control the dilution of the weld. OK Autrod 309LSi has good general corrosion resistance. The higher silicon content improves the welding properties such as wetting.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 309MoL		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 23 12 2 L	0.01	0.3	1.8	21.5	14.5	2.6		Tot <0.5	8	400	600	31	+20/110
	TÜV													

A continuous, solid, corrosion resistant wire of the 309LMo type. OK Autrod 309MoL is used for the overlay welding of unalloyed and low-alloyed steels and for welding dissimilar steels, such as 316L, to unalloyed and low-alloyed steels when Mo is essential.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 310		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 25 20 AWS/SFA 5.9 ER310	0.1	0.4	1.7	25	20			Tot <0.5		390	590	43	+20/175 -196/60

A continuous, solid, corrosion resistant, chromium-nickel wire for welding heat resistant austenitic steels of the 25% Cr, 20% Ni type. OK Autrod 310 has good overall oxidation resistance, especially at high temperatures, due to its high Cr content. The alloy is fully austenitic and is therefore sensitive to hot cracking. Common applications include industrial furnaces and boiler parts, as well as heat exchangers.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 312		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 29 9 AWS/SFA 5.9 ER312	0.1	0.5	1.7	29	8.5			Tot <0.5		610	770	20	+20/50

A continuous, solid, corrosion resistant, chromium-nickel wire for welding stainless steels of the 29% Cr, 9% Ni type. OK Autrod 312 has good oxidation resistance at high temperatures due to its high content of Cr. The alloy is widely used for joining dissimilar steels, especially if one of the components is fully austenitic, and steels that are difficult to weld, i.e. machine components, tools and austenitic-manganese steels.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 316L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G19 12 3 L AWS/SFA A5.9 ER316L	0.02	0.4	1.8	18.5	12	2.5	<0.08	Tot <0.5	8	440	620	37	+20/120 -60/95 -196/55

A continuous solid corrosion resistant chromium-nickel-molybdenum wire for welding of austenitic stainless alloys of 18% Cr, 8% Ni and 18% Cr - 10% Ni - 3% Mo-type. OK Autrod 316L has good overall corrosion resistance, particularly against corrosion in acid and chlorinated environments. The alloy has a low carbon content which makes it particularly recommended when there is a risk of intergranular corrosion. The alloy is widely used in the chemical and food processing industries as well as in shipbuilding and various types of architectual structures.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 316LSi		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 19 12 3 LSi AWS/SFA A5.9 ER316LSi	0.02	0.8	1.8	18.5	12	2.5	<0.08	Tot <0.5	7	440	620	37	+20/120 -60/95 -196/55
	CE, DB, DNV, TÜV													

A continuous, solid , corrosion resistant, chromium-nickel-molybdenum wire for welding austenitic stainless alloys of the 18% Cr -8% Ni and 18% Cr -10% Ni -3% Mo type. OK Autrod 316LSi has good overall corrosion resistance; in particular, the alloy has very good resistance to corrosion in acid and chlorinated environments. The alloy has a low carbon content which makes it particularly recommended when there is a risk of intergranular corrosion. The higher silicon content improves the welding properties such as wetting. The alloy is widely used in the chemical and food.

Solid wires for MIG/MAG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 318Si		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 19 12 3 NbSi AWS/SFA 5.4 E316L-16 DB, TÜV	0.08 **Cu** 0.1	0.8 **Nb** 0.7	1.5	19	12	2.7	<0.08	Tot <0.5	7	460	615	35	+20/100 -60/70

A continuous, solid corrosion resistant stabilised chromium–nickel-molybdenum wire for welding of Cr-Ni-Mo and Cr-Ni stabilised or non-stabilised steels. OK Autrod 318Si has a good overall corrosion resistance. The alloy is stabilised with niobium to improve the resistance against intergranular corrosion of the weld metal. The higher silicon content improves the welding properties, such as wetting. Due to stabilisation of niobium this alloy is recommended for service temperatures up to 400 °C.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 347Si		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 19 9 NbSi AWS/SFA A5.9 ER347Si DB, TÜV	0.04 **Cu** 0.1	0.7 **Nb** 0.6	1.7	19	9.8	0.1	<0.08	Tot <0.5	7	440	640	37	+20/110 -60/80

A continuous, solid, corrosion resistant, chromium-nickel wire for welding austenitic chromium-nickel alloys of the 18% Cr-8% Ni type. OK Autrod 347Si has good overall corrosion resistance. The alloy is stabilised with niobium to improve resistance to the intergranular corrosion of the weld metal. The higher silicon content improves the welding properties such as wetting. Due to the niobium content, this alloy is recommended for use at higher temperatures.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 385		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 20 25 5 CuL AWS/SFA 5.9 ER385 TÜV	0.01	0.3	1.6	20	25	4.7	1.4	Tot <0.5	0	340	540	37	+20/120

A continuous, solid, corrosion resistant, chromium-nickel-molybdenum-copper wire for welding austenitic stainless alloys of the 20% Cr, 25% Ni, 5% Mo, 1.5% Cu, low C types. OK Autrod 385 weld metal has good resistance to stress corrosion and intergranular corrosion and shows very good resistance to attack in non-oxidising acids. The resistance to crevice corrosion is better than that of ordinary 18% Cr, 8% Ni, Mo steels. The alloy is widely used in many applications related to the process industry.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 410NiMo		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 13 4	0.015	0.4	0.7	12	4.2	0.5	<0.3	Tot <0.5		600	840	17	-10/80

A continuous, solid welding wire of the 12% Cr, 4.5% Ni, 0.5% Mo type. OK Autrod 410NiMo is used for welding similar martentsitic and martensitic-ferritic steels in different applications, such as hydro turbines.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 430LNb		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G Z 17 L Nb	0.015 **Nb**>12xC	0.5	0.5	18.5	0.2	0.06	0.01	Tot <0.5		275	420	26	

A continuous ferritic, stainless, solid wire with a low carbon content, 18% Cr and stabilised with Nb, for welding similar and matching steels. OK Autrod 430 LNb has been developed and designed for the automotive industry and is used in the production of exhaust systems. The wire should be used when very good resistance to corrosion and thermal fatigue is required. Comments: Typical mechanical properties of weld assembly, base material AISI (EN 1.4512) 1.5mm.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 430Ti		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Ti**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 G Z 17 Ti	0.09	0.9	0.4	18	0.3	0.1	0.3	Tot <0.5		390	600	24	

A ferritic, stainless, solid wire with a content of 18% Cr and stabilised with 0.5% Ti for welding similar and matching steels. The alloy is also used for cladding on unalloyed and low-alloyed steels. OK Autrod 430Ti is also widely used in the automotive industry for the welding of manifolds, catalytic converters and exhaust pipes.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 16.95		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 18 8 Mn CE, DB, TÜV	0.1	1.0	6.5	18.5	8.5	0.1	<0.08	Tot <0.5		450	640	41	+20/130

A continuous solid, corrosion resistant chromium-nickel-manganese wire for welding austenitic stainless alloys of 18% Cr, 8% Ni, 7% Mn types. OK Autrod 16.95 has an overall corrosion resistance similar to that of the corresponding parent metal. The higher silicon content improves the welding properties, such as wetting. The product is a modified variant of ER307, basically with a higher Mn content to make the weld less sensitive to hot cracking. When used for joining dissimilar materials, the corrosion resistance is of secondary importance. The alloy is used in a wide range of applications across the industry, such as the joining of austenitic, manganese, work hardenable steels as well as armourplate and heat resistant steels.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 2209		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 22 9 3 NL AWS/SFA 5.9 ER2209 DNV, TÜV	0.01	0.6	1.6	23	9	3	0.1		45	600	765	28	+20/100 -20/85 -60/60

A continuous, solid, corrosion resistant, duplex wire for welding austenitic-ferritic stainless alloys of the 22% Cr, 5% Ni, 3% Mo type. OK Autrod 2209 has high overall corrosion resistance. In media containing chloride and hydrogen sulphide, the alloy has a high resistance to intergranular corrosion, pitting and especially to stress corrosion. The alloy is used in a variety of applications across all industrial segments.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 2307		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 18 8 Mn	0.02	0.4	0.5	23	7.0	<0.08	<0.5		40	515	700	30	+20/155 -40/115

A continous, solid, corrosion resistant duplex wire for welding austenitic-ferritic stainless alloys of the 21% Cr 1% Ni or 23% Cr, 4% Ni type. This lean duplex type is used for civil engineering, storage tanks, containers, etc. Welding should be done as for ordinary austenitic steels, but high amperages should be avoided and the interpass temperature should not exceed 150°C.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 2509		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN ISO 14343 G 25 9 4 NL	0.01	0.35	0.4	25	9.8	4	0.25		40	670	850	30	+20/150 -40/115

A continuous, solid, corrosion resistant, super duplex wire for welding austenitic-ferritic, stainless alloys of the 25% Cr, 7% Ni, 4% Mo, low C type. OK Autrod 2509 has high intergranular-corrosion, pitting and stress-corrosion resistance. The alloy is widely used in applications in which corrosion resistance is of the utmost importance, such as the pulp & paper, the offshore and gas industries.

Solid wires for MIG/MAG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 19.81		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 6059 (NiCr23Mo16) AWS/SFA 5.14 ERNiCrMo-13 TÜV	0.002	0.03	0.2	22.7	bal	15.4		Tot <0.5		550	800	45	-110/120
		Co 0.02	**Al** 0.15											

A continuous solid Ni-Cr-Mo electrode for welding high alloyed Ni-base materials, 9 %Ni steel and super austenitic steels of the 20Cr-25Ni with 4-6 % Mo type. Can also be used for welding carbon steel to Ni-based steel. The weld metal has a very good toughness and is corrosion resistant over a wide range of applications in oxidising and reducing media.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 19.82		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 6625 (NiCr22Mo9Nb) AWS/SFA 5.14 ERNiCrMo-3 TÜV, DNV	0,01	0,1	0,1	22.0	bal	9		Tot <0.5		500	780	45	-105/120 -196/110
		Cu <0.5	**Al** <0.4	**Fe** <2	**Ti** <0.4	**Nb+Ta** 3.65								

A continuous, solid, corrosion and heat resistant, Ni-Cr electrode for welding high-alloyed, heat resistant and corrosion-resistant materials, 9% Ni steels and similar steels with high notch toughness at low temperatures. It is also suitable for joining dissimilar metals of the types mentioned above. The weld metal has very good mechanical properties at high and low temperatures. Good resistance to pitting and stress corrosion.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 19.85		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 6082 (NiCr20Mn3Nb) AWS/SFA 5.14 ERNiCr-3 TÜV	0.02	0.1	3.0	20,0	bal			Tot <0.5					
		Cu <0.5	**Fe** <0.7	**Ti** <3	**Nb+Ta** 2.5									

A nickel-based, corrosion and heat resistant, 20% Cr, 3% Mo, 2.5% Nb electrode for the GMAW of high-alloyed steel, heat resistant steel, corrosion resistant steel, 9% Ni and similar steels with high notch toughness at low temperatures. It is also suitable for joining dissimilar metals of the type mentioned above. OK Autrod 19.85 is usually welded with pure Ar as the shielding gas.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 19.92		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 2061 (NiTi3) AWS/SFA 5.14 ERNi-1 TÜV	0.02	0.3	0.4		93			Tot <0.5		>200	>450	>25	+20/>130
		Cu 0.1	**Al** 0.1	**Ti** 3	**Fe** 0.2									

A continuous, solid nickel-based electrode alloyed with about 3% Ti for welding of high purity nickel (min 99.6%Ni), ordinary wrought nickel and nickel with reduced C content. The weld metal can be used in a wide range of applications involving corrosive media.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Autrod 19.93		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 4060 (NiCu30Mn3Ti) AWS/SFA 5.14 ERNiCu-7 TÜV	0.03	0.3	3		64			Tot <0.5					
		Nb 0.1	**Cu** 28	**Al** 0.03	**Ti** 2									

A continuous, solid nickel-based electrode alloyed with 30 % Cu for welding base materials of the same type. Can also be used to join these alloys to steel. The weld metal has good resistance to flowing seawater, high strength and toughness over a wide temperature range. Has also good resistance to hydrofluoric acid, sulphuric acid, alkalis etc. Can be used for welding similar types of base materials which are age-hardenable with small additions of Ti and Al. Usable for cladding on carbon steel with an intermediate layer of OK Autrod 19.92.

Welding of exhaust systems.

Today's automotive exhaust systems can be divided into two parts. The hot end includes the exhaust manifold, downpipe, flexible coupling and catalytic converter. The cold end includes the resonator, intermediate pipe, silencer and tail pipe. The ferritic 11% Cr alloys are popular choices for many exhaust components and systems. However, for the long-term durability, the higher chromium (17–20% Cr) ferritic stainless steel grades are often used. Welding stations may be designed for semiautomatic, mechanised, or fully robotic welding applications. The MIG/MAG-process using solid or metal cored stainless wires has evolved as one of the favourites for welding automotive exhaust systems.

Although today's car fuels are very low in sulphur, a certain amount of sulphur dioxide remains present in the exhaust gases. Together with the condense water, it forms sulphurous or sulphuric acid that deposits in the exhaust system. Ferritic stainless steels resist these acids very well, and have good heat resistance. They are increasingly preferred over austenitic stainless steels for exhaust systems, table 1.

Ferritic stainless steels are sensitive to the heat cycle generated by welding. Grain growth and hardening due to martensite formation can reduce the toughness of the steel and increase the risk of cracking in the heat-affected zone of the weld. This can be avoided by using special filler materials and the correct welding procedure.

- In general, preheating is needed when the carbon content of the steel is above 0.08% and the thickness of the steel exceeds 3mm.
- Welding should be carried out with the lowest possible heat input (pulsed arc).
- Un-stabilised steels require a post weld heat treatment at 700-750°C to avoid inter crystalline corrosion.
- Steels stabilised with titanium or niobium (columbium) do not need a post weld heat treatment.

Ferritic stainless steels can be welded with either austenitic or ferritic filler materials. The austenitic filler metal composition 18 8Mn (1.4370/ER 307, see table 2) is commonly applied. However, this type of welding consumable is sensitive to corrosion in sulphur containing media and can therefore only be used for exhaust systems when extremely low sulphur content fuels are used. Ferritic filler materials, such as type G13, G17 and G18 (EN440) provide the advantages of fatigue strength and corrosion resistance. The thermal expansion coefficient and the carbon content of both steel and weld metal are the same. Unfavourable stress peaks along the fusion line, and the diffusion of carbon, are therefore avoided. ESAB offers a comprehensive range of filler materials for ferritic stainless steels, see table 2.

Table 1: ferritic stainless steels.

W-Nr.	Composition	AISI/SAE
1.4002	X6CrAl13	405
1.4003	X2Cr11	-
1.4006	X12Cr13	410
1.4016	X6Cr17	430
1.4511	X3CrNb17	-
1.4512	X2Ti12	409
1.4513	X2CrMoTi17-1	-

Table 2: ESAB welding consumables for ferritic stainless steels.

ESAB	EN 12072	AWS A5.9
OK Autrod 430LNb	G Z 17 L Nb	ER430LNb
OK Autrod 430Ti	G Z 17 Ti	ER430
OK Autrod 409Nb	(G 13 Nb)	ER409Nb
OK Autrod 16.95	G 18 8 Mn	ER307
OK Tigrod 430Ti	WZ17Ti	ER430
OK Tigrod 16.95	W 18 8 Mn	ER307

Wires for TIG Welding

Welding Data

Stainless steel is TIG welded with direct current, straight polarity, i.e. with the electrode negative. Pulsed arc welding can be employed in order to obtain good control of the heat input. This is particularly advantageous for welding thin stainless steel sheet and for positional welding. A general rule for determining the arc current is 30-40 A per mm of material thickness.

TIG welding is particularly suitable for lighter materials; metals as thin as 0.3 mm can be welded successfully. For heavier materials, more than 5 to 6 mm thick, the TIG method is sometimes used to make root runs before filling with MIG or covered electrodes.
The electrode used in TIG welding of stainless steel can be made of pure tungsten or tungsten alloyed with thorium-oxide or lanthanum-oxide, which gives the electrode a better current carrying capacity than a pure tungsten electrode.
Electrodes alloyed with zirconium are preferably used for welding of aluminium.

Shielding gas

In TIG welding, the inert gases argon and/or helium are used. For manual TIG welding pure argon is recommended. For mechanised TIG a pure helium gas is sometimes used in order to increase the welding speed. For the same reason argon may also be mixed with helium or even a reducing gas. However, hydrogen is only permitted when the steel is austenitic.

When pickling cannot be performed and welding is done with non-slag electrodes for root runs of single sided welds, the root side of the weld must also be shielded from the atmosphere. If the gas shield is insufficient the bead and surrounding metal will be badly oxidised and possibly porous. Here either an inert gas or a reducing gas mixture can be used. An example of a reducing gas mixture is hydrogen in nitrogen. The amount of hydrogen is small, only 5-10%.
Sometimes it is practical to use the same gas for shielding and backing. It should be taken into account that nitrogen in the backing gas can affect the ferrite content in the weld. Nitrogen stabilises the austenitic structure and the ferrite content in the weld should not drop below two in order to minimise the risk for hot cracking.

Delivery forms

All OK Tigrod rods are supplied in round cardboard boxes with a net weight of 5 kg. This solution is a rigid fibre tube with a plastic lid that can be closed again after breaking the seal. The tube is PE-coated and gives very good resistance against moisture. The the bottom is octagonal to prevent the tube from rolling when stored.

Recommended current ranges.

Diam, mm	Pure tungsten,	Alloyed tungsten
Electrode		electrode
1.6	40-130	60-150
2.4	130-230	170-250
3.2	160-310	225-330
4.0	275-450	350-480

Wires for TIG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 308H		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 9 H AWS/SFA A5.9 ER308H	0.05	0.4	1.8	20	9.3	<0.3	<0.3	Tot <0.5		350	550	30	

Bare, corrosion resistant, chromium-nickel rods for welding austenic chromium-nickel alloys of the18% Cr-8% Ni type. OK Tigrod 308H has good general corrosion resistance. The alloy has a high carbon content, which makes it suitable for applications at higher temperatures. The alloy is used in the chemical and petrochemical industries for the welding of tubes, cyclones and boilers.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 308L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 9 L AWS/SFA A5.9 ER308L CE, DNV, TÜV	0.01 **Cu** 0.01	0.4	1.6	20	10	0.1	<0.08	Tot <0.5	9	480	625	37	+20/170 -80/135 -196/90

Bare, corrosion resistant, chromium-nickel TIG rod. OK Tigrod 308L has good general corrosion resistance. The alloy has a low carbon content which makes it particularly recommended when there is a risk of intergranular corrosion. The alloy is widely used in the chemical and food processing industries, as well as for pipes, tubes and boilers. Suitable for the joining of stainless steels of the18% Cr-8% Ni type with a low carbon content and Nb-stabilised steels of the same type if the service temperature does not exceed 350°C. It can also be used for welding Cr steels, except in sulphur rich environments.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 308LSi		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 9 LSi AWS/SFA A5.9 ER308LSi CE, DB, DNV, TÜV	0.01	0.8	1.8	20	10	0.1	<0.08		8	480	625	37	+20/170 -60/150 -110/140 -196/100

Bare, corrosion resistant, chromium-nickel rods for welding austenitic chromium-nickel alloys of the18% Cr-8% Ni type. OK Tigrod 308LSi has good overall corrosion resistance. The alloy has a low carbon content which makes it particularly recommended when there is a risk of intergranular corrosion. The higher silicon content improves the welding properties such as wetting. The alloy is widely used in the chemical and food processing industries, as well as for pipes, tubes and boilers.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 309L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 23 12 L AWS/SFA 5.9 ER309L CE, TÜV	0.015	0.4	1.7	24	13	0.1	<0.11	Tot <0.5	9	430	590	40	+20/160 -60/130 -110/90

Bare, corrosion resistant, chromium-nickel welding rod for welding 24%Cr, 13%Ni-alloyed types of steel. The alloy is also used for welding buffer layers on CMn steels and welding dissimilar joints. When using the wire for buffer layers and dissimilar joints, it is necessary to control the dilution of the weld. OK Tigrod 309L has good overall corrosion resistance. When used for joining dissimilar materials, the corrosion resistance is of secondary importance.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 309LSi		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 23 12 LSi AWS/SFA 5.9 ER309LSi CE	0.02	0.8	1.8	23	13	0.1	<0.09	Tot <0.5	9	475	635	32	+20/150 -60/150 -110/130

Bare, corrosion resistant, chromium-nickel welding rod for welding steels with similar composition, wrought and cast steels of the 23% Cr-12% Ni type. The alloy is also used for welding buffer layers on CMn steels and for welding dissimilar joints. When using the wire for buffer layers and dissimilar joints, it is necessary to control the dilution of the weld. OK Tigrod 309LSi has good overall corrosion resistance. The higher silicon content improves the welding properties such as wetting.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 309MoL		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 23 12 2 L DNV	0.01	0.3	1.6	22	14.5	2.7		Tot <0.5	8	400	600	40	+20/140
	Bare, corrosion resistant rod of the 309LMo type. OK Tigrod 309MoL is used for the overlay welding of unalloyed and low-alloyed steels and for welding dissimilar steels such as 316L to unalloyed and low-alloyed steels when Mo is essential.													

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 310		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 25 20 AWS/SFA 5.9 ER310	0.1	0.4	1.7	25	20			Tot <0.5		390	590	43	+20/175 -196/60
	Bare, corrosion resistant, chromium-nickel welding rod for welding heat resistant austenitic steels of the 25Cr-20Ni type. The wire has a high Cr content and provides good oxidation resistance at high temperatures. Applications include industrial furnaces and boiler parts, as well as heat exchangers.													

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 312		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 29 9 AWS/SFA 5.9 ER312	0.1	0.5	1.7	29	9	<0.3		Tot <0.5		610	770	20	+20/50
	Bare, corrosion resistant, chromium-nickel welding rod for welding materials of the 29% Cr, 9% Ni type. OK Tigrod 312 has good oxidation resistance at high temperatures due to its high content of Cr. The alloy is widely used for joining dissimilar steels, especially if one of the components is fully austenitc, and for steels that are difficult to weld, i.e. machine components, tools and austenitic-manganese steels.													

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 316L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 12 3 L AWS/SFA A5.9 ER316L CE, DNV, TÜV	0.01	0.4	1.6	18.5	12	2.5	<0.08	Tot <0.5	8	470	650	32	+20/175 -60/150 -110/120 -196/75
	Bare, corrosion resistant, chromium-nickel-molybdenum rod for welding austenitic stainless alloys of the 18% Cr-8% Ni and 18% Cr-10% Ni-3% Mo type. OK Tigrod 316L has good overall corrosion resistance, particularly to corrosion in acid and chlorinated environments. The alloy has a low carbon content which makes it particularly recommended when there is a risk of intergranular corrosion. The alloy is widely used in the chemical and food-processing industries, as well as in shipbuilding and various architectural structures.													

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 316LSi		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 12 3 LSi AWS/SFA A5.9 ER316LSi CE, DB, DNV, TÜV	0.01 **Cu** 0.1	0.8	1.7	18	12	2.5	<0.08	Tot <0.5	7	480	630	33	+20/175 -110/150 -196/110
	Bare, corrosion resistant, chromium-nickel-molybdenum rod for welding austenitic stainless alloys of the 18% Cr-8% Ni and 18% Cr-10% Ni-3% Mo type. OK Tigrod 316LSi has good overall corrosion resistance, particularly to corrosion in acid and chlorinated environments. The alloy has a low carbon content which makes it particularly recommended when there is a risk of intergranular corrosion. The higher silicon content improves welding properties, such as wetting. The alloy is widely used in the chemical and food-processing industries, as well as in shipbuilding and various architectural structures.													

Wires for TIG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 318Si		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 12 3 NbSi	0.04	0.8	1.5	19	12	2.5	<0.08	Tot <0.5	7	460	615	35	+20/40
		Cu	**Nb**											
	DB, TÜV	0.1	0.5											

Bare, corrosion resistant, stabilised, chromium-nickel-molybdenum wire for welding Cr-Ni-Mo and Cr-Ni stabilised or non-stabilised steels. OK Tigrod 318Si has good overall corrosion resistance. The alloy is stabilised with niobium to improve resistance to intergranular corrosion of the weld metal. The higher silicon content improves welding properties. such as wetting. Due to stabiliation by niobium, this alloy is recommended for service temperatures up to 400°C.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 347Si		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 19 9 NbSi AWS/SFA A5.9	0.04	0.8	1.5	20	10	0.1	<0.08	Tot <0.5	7	440	640	35	+20/90
	ER347Si	**Cu**	**Nb**											
	TÜV	0.1	0.7											

Bare, corrosion resistant, chromium-nickel rod for welding austenitic chromium nickel alloys of the 18% Cr-8% Ni type. OK Tigrod 347Si has good overall corrosion resistance. The alloy is stabilised with niobium to improve resistance to intergranular corrosion of the weld metal. The higher silicon content improves welding properties, such as wetting. Due to the niobium content, this alloy is recommended for use at higher temperatures.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 385		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 20 25 5 CuL AWS/SFA 5.9 ER385	0.01	0.4	1.8	20	25	4.5	1.5	Tot <0.5	0	340	540	37	+20/120
	TÜV													

Bare, corrosion resistant welding rod for welding austenitic stainless steels of the 20Cr-25Ni-4.5Mo-1.5Cu type. The weld metal has good resistance to stress corrosion and intergranular corrosion and shows very good resistance to attack in non-oxidising acids. The resistance to pitting and crevice corrosion is better than that of ordinary 18Cr-8Ni-Mo steels.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 410NiMo		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 13 4	0.01	0.3	0.7	12.3	4.5	0.5	<0.3	Tot <0.5		600	800	17	

Bare welding rod of the 420NiMo type alloyed with 13% Cr, 4.5% Ni and 0.5% Mo. This alloy is used for welding similar composition martensitic and martensitic-ferritic steels in different applications, such as hydro turbines. Stress relieved 600 °C, 2h.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 430Ti		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Ti**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W Z 17 Ti	0.09	0.7	0.4	17.5	0.3	0.1	0.5			>300	>450	>15	

A ferritic stainless solid rod with a content of 18% Cr and stabilised with 0,5% Ti for welding similar and matching steels. The alloy is also used for cladding on unalloyed and low-alloyed steels. OK Tigrod 430Ti is also widely used in the automotive industry for the welding of manifolds, catalytic coverters and exhaust pipes.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 16.95		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 18 8 Mn	0.08	0.7	6.5	18.5	8.5	0.1	<0.08	Tot <0.5		450	640	41	+20/130
	DB, TÜV													

Bare, corrosion resistant, chromium-nickel-manganese welding rod for welding austenitic stainless alloys of the 18% Cr, 8% Ni, 7% Mn type. OK Tigrod 16.95 has overall corrosion resistance similar to the corresponding parent metal. The higher silicon content improves welding properties, such as wetting. When used for joining dissimilar materials, the corrosion resistance is of secondary importance. The alloy is used in a wide range of applications across the industry, such as the joining of austenitic, manganese, work-hardenable steels, as well as armour plate and heat resistant steels.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 2209		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 22 9 3 NL AWS/SFA 5.9 ER2209	0.01	0.5	1.6	22.5	8.5	3.2	0.15	Tot <0.5	45	600	765	28	+20/100 -20/85 -60/60
	TÜV													

Bare, corrosion resistant, duplex welding rods for welding austenitic-ferritic stainless alloys of the 22% Cr, 5% Ni, 3% Mo type. OK Tigrod 2209 has high overall corrosion resistance. In media containing chloride and hydrogen sulphide, the alloy has high resistance to intergranular corrosion, pitting and especially to stress corrosion. The alloy is used in a variety of applications across all industrial segments.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 2509		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 12072 W 25 9 4 NL	0.01	0.35	0.4	25	9.8	4	0.25		40	670	850	30	+20/150 -40/115
	TÜV													

Bare, corrosion resistant, super duplex rod for welding austenitic-ferritic stainless alloys of the 25% Cr, 7% Ni, 4% Mo, low C type. OK Autrod 2509 has high intergranular corrosion, pitting and stress corrosion resistance. The alloy is widely used in applications where corrosion resistance is of the utmost importance, such as the pulp & paper, offshore and gas industries.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 19.81		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 6059 (NiCr23Mo16) AWS/SFA 5.14 ERNiCrMo-13	0.002	0.03	0.15	22.7	bal	15.4		Tot <0.5		550	800	45	-110/120
		Co 0.02	**Al** 0.15	**Fe** 0.5										
	TÜV													

Bare Ni-Cr-Mo rod for welding high-alloyed materials of the 20Cr-25Ni type with 4-6% Mo and Ni-based alloys of a similar type. It can also be used for welding carbon steels to Ni base steels. The weld metal has very good corrosion resistance over a wide range of applications in oxidising and reducing media.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 19.82		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 6625 (NiCr22Mo9Nb) AWS/SFA 5.14 ERNiCrMo-3	0,02	0.1	0.1	22.0	bal	9		Tot <0.5		550	780	40	-196/130
		Cu <0.5	**Al** <0.4	**Fe** <2	**Ti** <0.4	**Nb+Ta** 3.65								
	TÜV, DNV													

A nickel-based, corrosion and heat resistant 22% Cr, 9% Mo, 3.5% Nb rod for the GTAW of high-alloyed steel, heat resistant steel, corrosion resistant steel, 9% Ni steels and similar steel with high notch toughness at low temperatures. It is also suitable for joining dissimilar metals of the types mentioned above. OK Tigrod 19.82 is normally welded with pure Ar as the shielding gas.

Wires for TIG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 19.85		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 6082 (NiCr20Mn3Nb) AWS/SFA 5.14 ERNiCr-3 TÜV	0,02	0,1	3	20	>67			Tot <0.5					
		Cu	**Ti**	**Fe**										
		<0.5	<0.7	<3										

A nickel-based, corrosion and heat resistant 20% Cr, 3% Mn, 2.5% Nb rod for the GTAW of high-alloyed steel, heat resistant steel, corrosion resistant steel, 9% Ni steels and similar steels with good notch toughness at low temperatures. It is also suitable for joining dissimilar metals of the types mentioned above. OK Tigrod 19.85 is usually welded with pure Ar as the shielding gas.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 19.92		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 2061 (NiTi3) AWS/SFA 5.14 ERNi-1 TÜV	0.02	0.3	0.4		93			Tot <0.5		>200	>410	>25	+20/>130
		Cu	**Al**	**Ti**	**Fe**									
		0.1	0.1	3	0.2									

A bare nickel based rod alloyed with about 3% Ti for the welding of high purity nickel (min 99.6 % Ni), ordinary wrought nickel and nickel with reduced C content. The weld metal can be used in a wide range of applications involving corrosive media.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Tigrod 19.93		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
	EN 18274 S Ni 4060 (NiCu30Mn3Ti) AWS/SFA 5.14 ERNiCu-7 TÜV	0.03	0.3	3		64			Tot <0.5					
		Cu	**Al**	**Ti**	**Ta**	**Fe**								
		28	0.03	2	0.01	2								

Bare nickel based welding rods alloyed with 30 % Cu for the welding of base materials of the same type. Can also be used to join these alloys to carbon steel. The weld metal has good resistance to flowing seawater and has high strength and good toughness over a wide temperature range. It also has good resistance to hydrofluoric acid, sulphuric acid, alkalis etc. Can be used for welding similar types of base materials which are age-hardenable with small additions of Ti and Al.

Orbital-TIG – a great way to join pipes

ESAB supplies a complete range of orbital TIG-equipment, including power, for the mechanised welding of pipes. Although pipes have been welded using mechanised systems since the 1960's, the TIG-process still accounts for a considerable amount of manual welding. Yet, there are many good reasons to explore the use of orbital TIG-welding for applications ranging from single-run welding of thin-walled stainless pipes to multi run welding of thick-walled pipes, and even narrow-gap welding:

- Young welders are difficult to recruit.
- Operator ergonomics are improved significantly.
- Remote control and video control options.
- Increased duty cycle - higher productivity.
- Welding procedures repeatable - resulting in a consistent weld quality.
- Good control of the heat input.

Stationary vs. Orbital.

There are two main categories of mechanised welding systems:

- Stationary: the welding head has a fixed position while the pipe rotates.
- Orbital: the pipe has a fixed horizontal or vertical position while the welding head rotates.

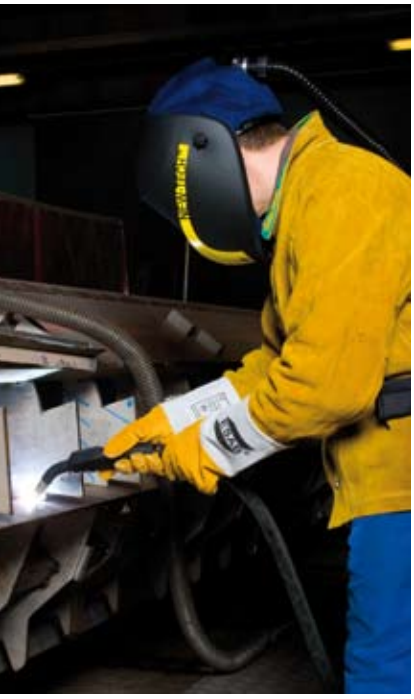
Orbital-TIG clamp-on welders.

Clamp-on pipe welding tools are used in orbital welding of small and medium-sized pipes. The tools can be equipped with a wire feeder. The maximum pipe diameter that can be handled is around 200 mm. Tools bigger than this are impractical and unwieldy. The same type of welding tool can be used to weld pipes within a specific diameter range. The PRB/PRC clamp-on welding tools, for example, cover the diameter ranges 17-49 mm, 33-90 mm and 60-170 mm. Normally, pipe standards are taken into consideration while designing welding heads, in order to make the scope of a single welding tool relatively broad. The clamp-on tool is locked onto the pipe in the welding position by a single movement of the hand, using the "self-locking pliers" principle. PRC welding tools can also be provided with the AVC function (Automatic Voltage Control of the arc length) and with a weaving action mechanism - both needed in the multi-run welding of thick-walled pipes. Clamp-on pipe welding tools can be either open (open tools) or enclosed (closed tools). Enclosed heads cover the entire weld area within a space filled with shielding gas. This is to prevent the hot weld zone from oxidation. These tools are used in for welds requiring extreme purity, such as pipes used in the pharmaceutical industry or titanium pipes. ESAB's PRD 100 carriage is particularly low (75 mm), which means that it will fit into confined spaces. Welding heads for narrow-gap welding of thick-walled pipes are also available.

Narrow gap welding

Narrow-gap welding with orbital TIG welders and special welding heads is a process adopted over recent years, figure 6. By narrowing the cross section of the joint, the joint volume is reduced by a factor of 2-3, depending on the wall thickness, figure 7. The bevel angle of a conventional U-groove is 10-20°, but in narrow-gap welding it is a mere 2-6°. A narrow-gap weld is usually made by welding "bead-on-bead" - so one run per layer.

Tubular cored wires for MIG/MAG welding



Traditionally, the most popular processes for the welding of stainless steels have been manual arc followed by MIG, TIG and submerged arc. Solid wire is faster than manual arc, but can lack appeal due to spatter levels, a heavily oxidised weld deposit or fusion defects related to low current positional welding using dip transfer.

The use of TIG and submerged arc will continue due to their particular attributes for certain applications. The range of available cored wires offer the fabricator a genuine opportunity for increased quality and productivity over solid wire MAG and manual arc electrodes.
The benefits can be summarised as:

- Up to 30% increase in weld metal deposition rate over solid wire and four times that of manual arc, resulting in faster welding speeds which in turn reduce distortion.

- Wires to permit welding of all the common grades of stainless steels both for the downhand / horizontal-vertical and out of position welding.

- Moisture regain is minimal ensuring that start porosity is eliminated.

- The rutile types are designed for use with Ar/CO_2 or CO_2 shielding gas. The latter serves to reduce gas costs and radiated heat is also significantly lower giving greater operator comfort.

- Individual batch testing of weld metal composition means that the most stringent of quality standards are met.

Shield-Bright Wire Series
The range of wires within the Shield-Bright series have been especially designed to produce superior operability for all-positional welding applications. Regardless of position, the weld deposit will be flat, which is a quality provided by the faster freezing slag. In having a rutile based slag system they always operate in the spray transfer mode and can be used at high currents and hence give high deposition rates.

Slag release is not a problem even in V butt joints and when not totally self releasing, the slag can be removed with the very minimum of chipping. The spatter levels are almost non-existent which allows for additional savings in cleaning time. This is due to the extremely stable arc action under spray transfer conditions which ensures that the maximum possible efficiency is achieved from the wire. Typical efficiencies will be 80-85% depending on the diameter and current used.

With regard to productivity, the 1.2mm types are in excess of three times faster than 3.2mm manual arc electrodes and almost twice as fast as 0.9mm solid wires in the vertical position.

Shield-Bright X-tra Wire Series
It is not possible to produce a consumable that operates with equal performance in every position and the Shield-Bright X-tra range was introduced especially for welding in the flat and horizontal vertical positions. This range complements the Shield-Bright range by designation and composition to produce an exceptional partnership for stainless steel welding.

The Shield-Bright X-tra series can in fact be used for vertical upwards welding, but their more fluid slag, which is for optimum downhand operation, does impose certain

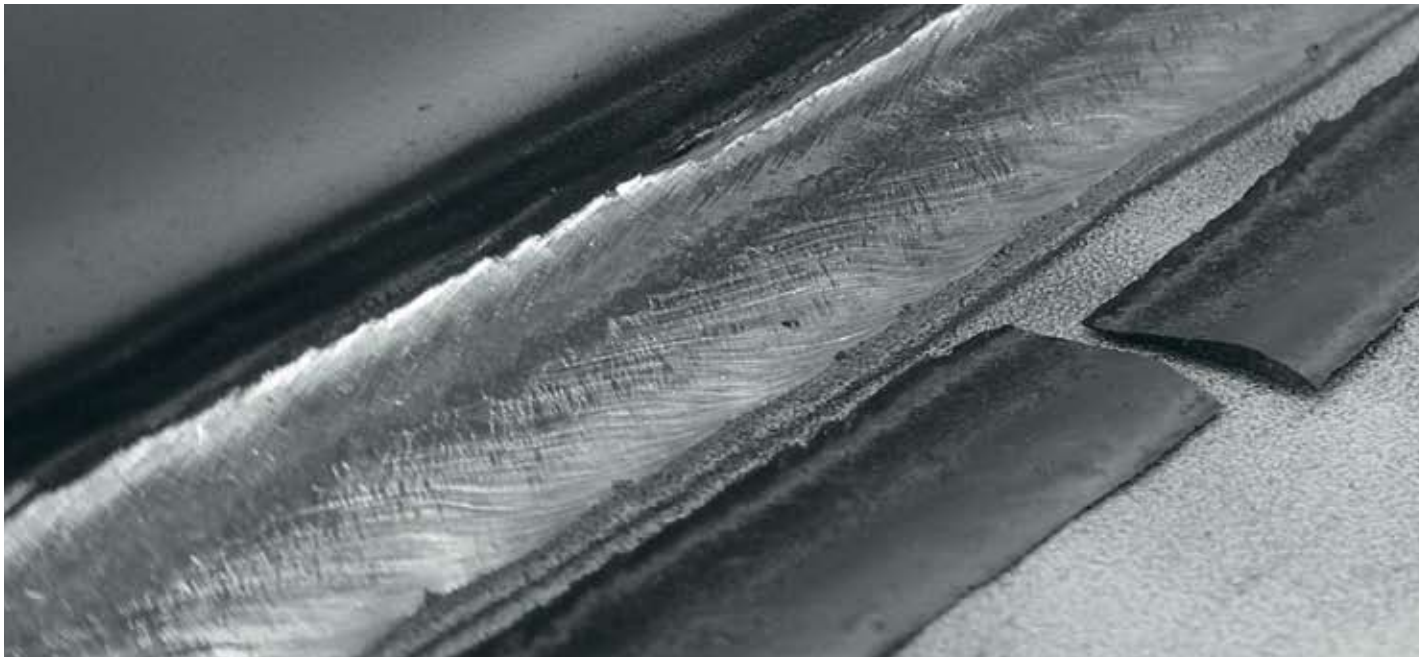
limitations. Single pass or narrow deposits are not possible using the vertical-up technique due to excessive heat build up. The weaving technique is excellent on thicker plate when there is greater heat sink and additional dissipation from the weaving. Single passes for fillet welding and the root areas of butt joints should be completed using the vertical downwards technique, but there is a reduction in depth of penetration. This technique is restricted to the 1.2mm sizes, and can also be used to advantage for rapid welding of sheet material.

The operability of the Shield-Bright X-tra wires is exceptional combining extreme ease of use, high performance with regard to metal deposition and a weld appearance comparable to the latest generation of manual arc electrodes. As with rutile based C/Mn types the spray transfer mode is used at all acceptable current levels even down to 100A with the 1.2mm size. Such a facility affords high welding speeds, reduced operator fatigue, better fusion and a low risk of defects when compared to solid wire.

Although normally used at higher current levels than the Shield-Bright series, spatter is still virtually non-existent and the thin slag is generally self releasing leaving a bright smooth weld finish. This is an obvious advantage on fabrications where subsequent dressing and polishing is required, especially in the case of fillet joints.

Shielding gases

A variety of shielding gases can be used with the flux cored types due to the greater tolerance available, although the higher the CO_2 content the higher the carbon content and the lower the alloy and ferrite content. However, the changes are marginal with C increasing by 0.01% and Cr decreasing by 0.1% progressively between pure Ar through to pure CO_2. The influence of shielding gas on mechanical properties is also minimal to the extent that the changes may be disregarded. With regard to running characteristics the CO_2 content should not be less than 20% as a lower content will produce inferior arc manipulation.



Tubular cored wires for MIG/MAG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 308L X-tra		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2 and 1.6	EN ISO 17633-A T 19 9 L R C 3 T 19 9 L R M 3 AWS/SFA A5.22 E308LT0-1 E308LT0-4 ABS, DNV, LR, TÜV	0.02	0.9	1.4	19.6	9.9	0.1	0.15	410	580	40

Shield-Bright 308L X-tra is a rutile flux-cored wire designed for the downhand and horizontal-vertical (fillet) welding of stainless steels containing 18-20%Cr/8-12%Ni. In addition to the 304L and 308L varieties, it is also suitable for welding the stabilised 321 and 347 types. Shield-Bright 308L X-tra has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 309L X-tra		**C**	**Si**	**Mn**	**Cr**	**N**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2 and 1.6	EN ISO 17633-A T 23 12 L R C 3 T 23 12 L R M 3 AWS/SFA A5.22 E309LT0-1 E309LT0-4 ABS, DNV, TÜV	0.03	0.8	1.4	24.5	12.5	0.1	0.10	480	600	35

Shield-Bright 309L X-tra is a rutile cored wire designed for the downhand and horizontal-vertical (fillet) welding of stainless steels to carbon or low alloy steels and for the first layer cladding of carbon and low alloy steels. Shield-Bright 309L X-tra has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced therefore time is saved on cleaning the welds. This cored wire provides high X-ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at high speeds.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 309LMo X-tra		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	EN ISO 17633-A T 23 12 2 L R C 3 T 23 12 2 L R M 3 AWS/SFA A5.22 E309LMoT0-1 E309LMoT0-4	0.03	0.8	1.2	23.5	13.5	2.5	0.10	550	690	30

Shield-Bright 309LMo Xtra is a flux-cored, tubular wire for use in the downhand and horizontal-vertical positions, producing weld metal of the 309+ MoL type composition. The austenitic-ferritic weld deposit has an exceptionally high resistance to hot cracking when welding dissimilar steels. Applications of this kind include the welding of buffer layers for acid-resistant clad steels and surfacing. It is also ideally suited to the welding of mild and low-alloy steels to a wide range of stainless steels.
Shield-Bright 309LMo X-tra has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 316L X-tra		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2 and 1.6	EN ISO 17633-A T 19 12 3 L R C 3 T 19 12 3 L R M 3 AWS/SFA A5.22 E316LT0-1 E316LT0-4 ABS, LR, TÜV	0.03	0.6	1.3	18.5	12	2.7	0.15	450	580	36

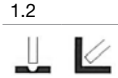
Shield-Bright 316L X-tra is a rutile flux-cored wire designed for the downhand and horizontal-vertical (fillet) welding of 316 low-carbon type 18-20Cr10-14Ni2-3Mo steels. The composition also ensures that the stabilised types can be welded with equal success. Shield-Bright 316L X-tra has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 317L X-tra		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2 and 1.6	AWS/SFA A5.22 E317LT0-1 E317LT0-4	0.03	0.7	1.5	19.0	12.5	3.5	0.15	480	580	35

Shield-Bright 317L X-tra is a rutile cored wire designed for the downhand and horizontal-vertical (fillet) welding of 317 and 317L steels. Shield-Bright 317L X-tra has excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced therefore time is saved on cleaning the welds. This cored wire provides high X-ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at high speeds.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 347 X-tra		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	EN ISO 17633-A T 19 9 Nb R M 3 AWS/SFA A5.22 E347T0-1 E347T0-4	0.04	0.5	1.6	19	9.6	0.1	0.04	460	610	41
		Nb 0.8									

Shield-Bright 347 X-tra is a rutile cored wire designed for the downhand and horizontal-vertical (fillet) welding of 321 and 347 steels. Shield-Bright 347 X-tra has excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. It is a “welder-friendly” wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced therefore time is saved on cleaning the welds. This cored wire provides high X-ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at high speeds.

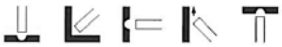


Tubular cored wires for MIG/MAG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 308L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	EN ISO 17633-A T 19 9 L P M 2 / T 19 9 L P C 2 AWS/SFA A5.22 E308LT1-1 E308LT1-4 ABS, CWB, TÜV	0.03	0.9	1.2	19	10	0.1	0.15	410	580	44

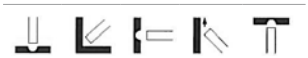
Shield-Bright 308L is a rutile flux-cored wire designed for the all-positional welding of stainless steels containing 18-20%Cr/8-12%Ni. In addition to the 304L and 308L varieties, it is also suitable for welding the stabilised 321 and 347 types. Shield-Bright 308L has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding, allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 309L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	EN ISO 17633-A T 23 12 L P C 2 T 23 12 L P M 2 AWS/SFA A5.22 E309LT1-1 E309LT1-4 ABS, GL, TÜV	0.03	0.9	1.3	24	12.5	0.1	0.10	480	600	35



A flux-cored, tubular wire depositing weld metal of the 309L type for use in all welding positions. Apart from joining these steels, the weld metal ferrite content ensures that it is suitable for dissimilar applications, as well as joining difficult-to-weld steels. Shield-Bright 309L has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding, allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 309LMo		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	AWS/SFA A5.22 E309LMoT1-1 E309LMoT1-4	0.03	0.8	1.2	23.5	13.5	2.5	0.10	480	620	30



Shield-Bright 309LMo is a rutile cored wire designed for the all-positional welding of 316 clad steels on the first pass in cladding steels or for welding dissimilar steels such as Mo containing austenitic steels to carbon steels. Shield-Bright 309LMo has excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced therefore time is saved on cleaning the welds. This cored wire provides high X-ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at high speeds.

Shield-Bright 316L

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 316L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	EN ISO 17633-A T 19 12 3 L P M 2 / T 19 12 3 L P C 2 AWS/SFA A5.22 E316LT1-1 E316LT1-4 ABS, CWB, TÜV	0.03	0.6	1.3	18.5	12	2.7	0.15	450	580	40

Shield-Bright 316L is a rutile flux-cored wire designed for the all-positional welding of 316 low-carbon type 18-20Cr10-14Ni2-3Mo steels. The composition also ensures that the stabilised types can be welded with equal success.. Shield-Bright 316L has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding, allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

Shield-Bright 317L

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 317L		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	AWS/SFA A5.22 E317LT1-1 E317LT1-4	0.03	0.9	1.2	19.5	13.0	3.5	0.15	480	620	35

Shield-Bright 317L is a rutile cored wire designed for the all-positional welding of 317 and 317L stainless steels. Shield-Bright 317L has excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at high speeds.

Shield-Bright 347

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 347		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 or CO_2 **Size (mm)** 1.2	AWS/SFA A5.22 E347LT1-1 E347LT1-4	0.03	0.9	1.2	19.5	10.0	0.1	0.10	520	650	35

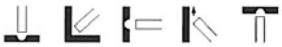
Shield-Bright 347 is a rutile cored wire designed for the all-positional welding of 321 and 347 stainless steel. It can also be used for the welding of 302, 304 and sometimes 304L grades. Shield-Bright 347 has excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at high speeds.

Tubular cored wires for MIG/MAG welding

	Classifications & approvals	Typical chemical composition all weld metal (%)								Typical mechanical properties all weld metal		
OK Tubrod 14.27		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**N**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 **Size (mm)** 1.2	EN ISO 17633-A T 22 9 3 N L P M 2 T 22 9 3 N L P C 2 AWS/SFA A5.22 E2209LT1-4 / E2209LT1-1 ABS, DNV, LR, TÜV	0.03	0.9	1.0	22.6	9	3	0.15	0.15	637	828	26

OK Tubrod 14.27 is a rutile flux-cored wire designed for the all-positional welding of duplex stainless steels. Ideally suited for the all-positional welding of SAF 2205, FAL223, AF22, NK Cr22. and HY Resist 22/5 duplex steels. OK Tubrod 14.27 has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding, allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)								Typical mechanical properties all weld metal		
OK Tubrod 14.28		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**N**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 **Size (mm)** 1.2		0.03	0.6	0.9	25.2	9.2	3.9	0.15	0.25	700	870	18



OK Tubrod 14.28 is a rutile flux-cored wire designed for the all-positional welding of super duplex stainless steels. The weld metal composition gives a high resistance to pitting corrosion. OK Tubrod 14.28 has excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding, allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires, no silica islands are produced, therefore time is saved on cleaning the welds. This cored wire provides high X-Ray quality welds. One-sided root runs in open joints can be welded on ceramic weld metal supports at a very high productivity rate.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
Shield-Bright 410 NiMo		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Rutile **Polarity** DC+ **Shielding gas** Ar/15-25%CO_2 **Size (mm)** 1.2 and 1.6	**AWS/SFA A5.22** E410NiMoT1-4	0.01	0.7	0.5	11.3	4.1	0.5	0.03	760	900	17

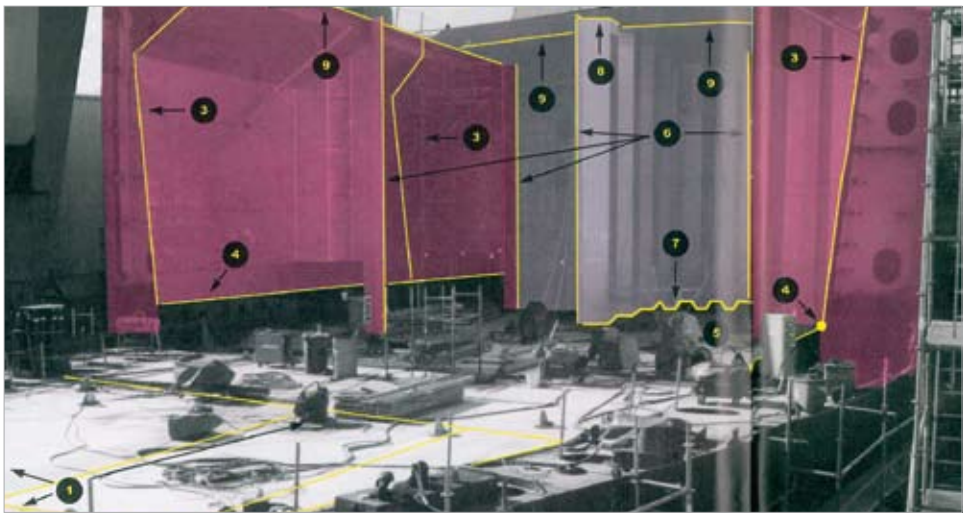
Shield-Bright 410 NiMo is an all-positional cored wire designed for the fabrication and repair welding of pelton wheels and other hydro turbine components. It is for the welding of UNS S41 500 wrought stainless steel and other similar 13Cr4NiMo type castings. To be used with Ar/15-25%CO_2 shielding gas. The fast freezing slag supports the weld metal in positional welding allowing deposition rates that can not be equaled by stick electrodes or solid wires (up to 4kg/h in PF, 3F position). It is a "welder-friendly" wire, always operating in the favourable spray arc mode. The slag is self-lifting or easily detached leaving clean and flat welds with good penetration and a very smooth wetting onto the plate edges. Unlike solid wires no silica islands are produced therefore time is saved on cleaning the welds.

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
OK Tubrod 15.30		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Metal cored	EN ISO 17633-A T 19 9 L M M 2	0.02	0.7	1.3	18.8	9.8	0.1	0.10	340	550	45
Polarity DC+	DB, TÜV										
Shielding gas Ar/2%O_2	OK Tubrod 15.30 is a stainless 308L grade metal cored wire designed for high deposition welding of 301, 302 304 and 304L grades. The wire produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in the spray mode of arc transfer with with Ar/2%O_2 shielding gas.										
Size (mm) 1.2											

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
OK Tubrod 15.31		**C**	**Si**	**Mn**	**Cr**	**N**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Metal cored	EN ISO 17633-A T 19 12 3 L M M 2	0.02	0.7	1.2	17.6	11.6	2.7	0.10	416	575	37
Polarity DC+	DB, DNV, LR, TÜV										
Shielding gas Ar/2%O_2	OK Tubrod 15.31 is a stainless 316L grade metal cored wire designed for high deposition welding. The wire produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in the spray mode of arc transfer with with Ar/2%O_2 shielding gas.										
Size (mm) 1.2											

	Classifications & approvals	Typical chemical composition all weld metal (%)							Typical mechanical properties all weld metal		
OK Tubrod 15.34		**C**	**Si**	**Mn**	**Cr**	**N**	**Mo**	**Cu**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**
Type Metal cored	EN ISO 17633-A T 18 8 Mn M M 2	0.10	0.7	6.7	18.5	8.7	0.1	0.10	430	635	39
Polarity DC+	DB, TÜV										
Shielding gas Ar/2%O_2	OK Tubrod 15.34 is a stainless 307 grade metal cored wire designed for the high deposition welding of armour steel, austenitic-manganese steels and dissimilar steels. The wire produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in the spray mode of arc transfer with with Ar/2%O_2 shielding gas.										
Size (mm) 1.2											

Construction of chemical tankers with cored wires



1 Tank floor from pre-fabricated plates.

Position: PA/1G
Root & 1st pass: FCAW with OK Tubrod 14.37, welded manually onto ceramic backing strip.
Filling: SAW with
OK Autrod 2209/OK Flux 10.93

2 Connection between tank floor and carbon steel hull

Position: PA/1G
Root & 1st pass: FCAW with OK Tubrod 14.22, welded manually onto ceramic backing strip.
Filling: SAW with
OK Autrod 309L/OK Flux 10.93

3 Connection between corrugated bulkheads and 6 between tank side walls

Position: PA/3G
Root: FCAW with OK Tubrod 14.27, welded manually onto ceramic backing strip
Filling: FCAW with OK Tubrod 14.27, welded manually.

4 Connection between vertical tank wall and angled side wall

Position: PC/2G
Root: FCAW with OK Tubrod 14.27, welded manually onto ceramic backing strip.
Filling: FCAW with OK Tubrod 14.27, welded manually .

5 Connection between angled side wall and tank floor

Position: PC/2G
Multi-layer T-joint; full penetration.
FCAW with OK Tubrod 14.27, manually.
Sealing: SMAW with OK67.50

7 Connection between corrugated bulkheads and tank floor

Position: PC/2G
Root: FCAW with OK Tubrod 14.27, manually welded onto cylindric ceramic backing.
Filling: FCAW with OK Tubrod 14.27, welded manually.

8 Connection between corrugated bulkheads and tank cover

Position: PC/2G
Root: FCAW with OK Tubrod 14.27, manually welded onto cylindric ceramic backing.
Filling: FCAW with OK Tubrod 14.27, welded manually.

9 Connection between tank cover and between tank covers and side walls

Position: PA/1G
Root & 1st pass: FCAW with OK Tubrod 14.37, manually welded onto ceramic backing strip.
Filling: FCAW with OK Tubrod 14.37

The ESAB series of cored wires for standard duplex stainless steel consist of the all-position type, OK Tubrod 14.27 and the downhand type, OK Tubrod 14.37.
They both provide fabricators with optimal welding characteristics and productivity for manual or mechanised welding.

OK Tubrod 14.27 is a very versatile consumable, suited for all welding positions, including pipe welding in combination with the TIG process for rooting. Very fast vertical down welding of fillet welds is possible for parts that allow to be attached without secure root penetration. Many fabricators will standardise on this type, when the majority of the work involves positional welding.
Both types have very clear advantages compared with MMA and GMAW, reviewed below.

Advantages over MMA

- Higher productivity in general due to higher duty cycle
- Deposition rate in positional welding almost 3 times higher.
- Very economic deposition of root passes, with less welder skill needed
- No stub-end waste.

Advantages over GMAW

- Up to 150% higher productivity in positional welding
- Excellent performance with conventional power sources; no expensive pulsed arc equipment needed.
- Use of normal 80%Ar/20%CO2 shielding gas; use of expensive high Ar mixtures is avoided. Fabricators have an option to standardise on one gas when welding both unalloyed and stainless steels.
- Less oxidation of weld surface due to protective action of slag
- No grinding or sealing needed for the reverse side of the root

Fluxes for submerged arc welding

Definition
Submerged are welding (SAW) is a method in which the heat required to fuse the metal is generated by an arc formed by an electric current passing between the electrode and the work-piece. A layer of granulated mineral material, known as submerged arc welding flux, covers the tip of the welding wire, the arc and the work-piece. There is no visible arc and no sparks, spatter or fume. The electrode may be a solid or cored wire or a strip.
SAW is normally a mechanised process. The welding current, arc voltage, and travel speed all affect the bead shape, depth of penetration and chemical composition of the deposited weld metal. Since the operator cannot observe the weld pool, great reliance is placed on parameter setting and positioning of the electrode.

Flux wire and strip packages
ESAB delivers fluxes in 25 kg paper bags, some types in 20 kg paper bags. Each bag has a polyethylene inlay in order to prevent the flux from moisture pick-up from the surrounding atmosphere. The palettes with flux bags again are protected against moisture by wrap or shrink foil.

For a more robust package ESAB can supply fluxes in steel buckets with 25 to 30 kg flux. Buckets have a soft rubber band in the lid which makes them moisture tight.

The packing material is fully recyclable and thus environmentally friendly. The majority of the bag packing material is recycled as paper.

Stainless and Ni based SAW welding wires are usually delivered on 25 kg wire baskets.

The SAW welding wires up 2.0 mm can also be delivered in 475 kg octagonal cardboard drums, Marathon pac. Wire is pre-twisted for straight delivery. No decoiling stand needed. All

packaging materials are non-returnable, but fully recyclable.

The strip electrodes are delivered in cold rolled condition in 25 kg or 50 kg and 100 – 200 kg coils with an inner diameter of 300 mm. The standard thickness is 0.5 mm with widths normally 30, 60 and 90 mm.
Other weight of coils or dimensions of strips are available on request.

Fluxes for submerged arc welding

OK Flux 10.05

Basicity index
1.1

Density
~ 0.7 kg/dm³

Grain size
0.25-1.6mm

Slag type
Slightly Basic

Polarity
DC+

Alloy transfer
none

Classifications & approvals	Typical chemical composition all weld metal (%)								
	C	Si	Mn	Cr	Ni	Mo	N	FN	Others
EN 760: SA CS 2 DC									
With OK Band 309L									
EN 12072: S 23 12 L AWS/SFA 5.9: EQ309L									
TÜV									
With OK Band 308L*	*2nd layer on mild steel								
EN 12072: S 19 9 L AWS/SFA 5.9: EQ308L	0.02	0.6	1.0	19.0	10.5		0.03	6	
With OK Band 347*	*2nd layer on mild steel								
EN 12072: S 19 9 Nb AWS/SFA 5.9: EQ347	0.02	0.7	1.1	19.0	10.5		0.03	8	Nb=0.35
With OK Band 316L*	*2nd layer on mild steel								
EN 12072: S 19 12 3 L AWS/SFA 5.9: EQ316L	0.02	0.7	1.1	18.0	13.0	2.5	0.02	7	
TÜV									

OK Flux 10.05 is a aluminate basic, agglomerated flux designed for submerged strip cladding with Cr, CrNi, CrNiMo and stabilised stainless strips of the AWS EQ300 type. OK Flux 10.05 is ESAB's standard flux for internal overlay welding on mild or low alloyed steel. It has very good welding characteristics, gives a smooth bead appearance and easy slag removal. For chemical and petrochemical plants, pressure vessels, storage tanks, nuclear power generation, pulp and paper, civil constructions, etc.

OK Flux 10.06, OK Flux 10.06F

Basicity index
1.0

Density
~ 1.0 kg/dm³

Grain size
0.25-1.4mm

Slag type
Neutral

Polarity
DC+

Alloy transfer
Cr, Ni and Mo-alloying

Classifications & approvals	Typical chemical composition all weld metal (%)								
	C	Si	Mn	Cr	Ni	Mo	N	FN	Others
EN 760: SA CS 2 CrNiMo DC									
With OK Band 309L*	*1rd layer cladded with OK Band 309L 0,5x60 mm and OK Flux 10.06F.								
EN 12072: S 23 12 L AWS/SFA 5.9: EQ309L	0.03	0.6	0.8	18.6	11.9	2.5	0.05	6.7	
With OK Band 309L**	**1rd layer cladded with OK Band 309L 0,5x90 mm and OK Flux 10.06.								
EN 12072: S 23 12 L AWS/SFA 5.9: EQ309L	0.03	0.6	0.8	18.6	11.9	2.5	0.05	6.7	

OK Flux 10.06 and OK Flux 10.06F are neutral Cr, Ni and Mo-alloying agglomerated fluxes designed for submerged strip cladding at high welding speed with an AWS EQ309L strip. They produce 316L overlay weld metal in one layer e.g. for internal overlay welding of paper fibre digester drums. The slag is self-lifting or easily detached, leaving a clean and flat overlay. OK Flux 10.06F is especially designed for welding with 60 mm wide strip, OK Flux 10.06 for 90 mm wide strip. For chemical plants, paper production, storage tanks, etc.

OK Flux 10.07

Basicity index
1.0

Density
~ 1.0 kg/dm³

Grain size
0.25-1.4mm

Slag type
Neutral

Polarity
DC+

Alloy transfer
Ni and Mo-alloying

Classifications & approvals	Typical chemical composition all weld metal (%)								
	C	Si	Mn	Cr	Ni	Mo	N	FN	Others
EN 760: SA CS 3 NiMo DC									
With OK Band 430*	*2rd layer cladded with OK Band 430 0.5x60 mm.								
EN 12072: S 17	0.05	0.6	0.15	13.0	4.0	1.0			

OK Flux 10.07 is a neutral Ni and Mo-alloying agglomerated flux designed for submerged strip cladding with an AWS EQ430 strip producing an overlay weld metal of 14Cr-4Ni-1Mo and a hardness of 370-420 HB. It produces a ferritic weld metal with an enhanced toughness and cracking resistance during service. For cladding on shafts, pistons, continuous cast rolls and other parts of repair and maintenance segment.

OK Flux 10.10

Basicity index
4.0

Density
~ 1.0 kg/dm³

Grain size
0.2-1.0mm

Slag type
High Basic

Polarity
DC+

Alloy transfer
none

Classifications & approvals	Typical chemical composition all weld metal (%)								
OK Flux 10.10	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**	**Others**
EN 760: Not applicable									
With OK Band 309L ESW*	* 1rd layer, welded on 2.25Cr1Mo steel								
EN 12072: Not applicable AWS/SFA 5.9: Not applicable	0.03	0.4	1.2	19.0	10.0		0.05	4	
With OK Band 309LNb ESW*	* 1rd layer, welded on 2.25Cr1Mo steel								
EN 12072: Not applicable AWS/SFA Not applicable	0.03	0.4	1.3	19.0	10.0		0.05	4	Nb=0.4
TÜV									
With OK Band 309LMo ESW*	* 1rd layer, welded on 2.25Cr1Mo steel								
EN 12072: Not applicable AWS/SFA Not applicable	0.03	0.4	1.1	18.0	12.5	2.8	0.04	6	

OK Flux 10.10 is a high basic, agglomerated flux designed for electroslag strip cladding with austenitic stainless strips. OK Flux 10.10 is the ESAB standard flux for electroslag cladding with various strips, for instance, OK Band 309L ESW. The flux, developed for high roductivity strip cladding, gives a smooth bead appearance, very good welding properties and easy slag removal. Can be used for single or multi layer cladding. However, the process requires a special welding head and a power source of at least 1600 A. For chemical and petrochemical plants, pressure vessels, storage tanks, nuclear reactor components and power generation.

OK Flux 10.11

Basicity index
5.4

Density
~ 1.0 kg/dm³

Grain size
0.2-1.0mm

Slag type
Very High Basic

Polarity
DC+

Alloy transfer
none

Classifications & approvals	Typical chemical composition all weld metal (%)								
OK Flux 10.11	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**	**Others**
EN 760: SA AF 2 DC									
OK Band NiCrMo3*	*1st layer on mild steel								
EN 18274: S Ni6625 (NiCr22Mo9Nb) AWS/SFA 5.14: ER NiCrMo-3	0.025	0.45	0.07	19.6	Bal.	8.1	0.01	4	Nb+Ta=2.9, Fe=7
OK Band NiCrMo3**	**2nd layer on mild steel								
EN 12072: 18274: S Ni6625 (NiCr22Mo9Nb) AWS/SFA 5.14: ER NiCrMo-3	0.02	0.5	0.03	21.0	Bal.	8.1	0.01	4	Nb+Ta=3.2, Fe=4

OK Flux 10.11 is a high basic, agglomerated flux designed for electroslag strip cladding with stainless, fully austenitic and Ni-based strips. Can be used for single or multi layer cladding with higher welding speed. Ok Flux 10.11 has very good welding characteristics, gives a smooth bead appearance and easy slag removal. For the chemical processing industry, pollution control equipment, marine equipment, nuclear reactor components, pump shafts.

OK Flux 10.14

Basicity index
4.4

Density
~ 1.0 kg/dm³

Grain size
0.2-1.0mm

Slag type
High Basic

Polarity
DC+

Alloy transfer
none

Classifications & approvals	Typical chemical composition all weld metal (%)								
OK Flux 10.14	**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**	**Others**
EN 760: Not applicable									
With OK Band 309LNb *	* 1rd layer, welded on mild steel.								
EN 12072: S 23 12 L Nb (NiCr22Mo9Nb) AWS/SFA 5.9:	0.03	0.5	1.6	19.0	10.0		0.02	5	Nb=0.6

OK Flux 10.14 is a high basic, agglomerated flux designed for electroslag strip cladding with austenitic stainless strips, especially OK Band 309LNb. It is flux for very high productivity strip cladding, up to about 35 cm/min. Can be used for single or multi layer cladding, gives a smooth bead appearance, very good welding properties and easy slag removal. However, the process requires a water cooled welding head and a power source of at least 2400 A. For chemical and petrochemical plants, pressure vessels, storage tanks, nuclear reactor components and power generation.

Fluxes for submerged arc welding

OK Flux 10.16

Basicity index
2.4

Density
~ 1.2 kg/dm³

Grain size
0.25-1.6mm

Slag type
Basic

Polarity
DC+

Alloy transfer
None

Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
	C	Si	Mn	Cr	Ni	Mo	N	Other	FN	$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4/A5 (%)	CVN (°C/J)
EN 760: SA AF 2 DC													
With OK Autrod 19.82													
EN 18274: S Ni6625 (NiCr22Mo9Nb) AWS/SFA 5.14 ER NiCrMo-3	0.01	0.3	0.3	21	Bal.	9		Nb+Ta=3 Fe=3		425	700	40	+20/130 -196/80
With OK Autrod 19.85													
EN 18274: S Ni6082 (NiCr20Mn3Nb) AWS/SFH 5.14 ERNiCr-3	0.01	0.3	3.2	19	Bal.	0.5		Nb=2.5		360	600	35	+20/140 -196/100
With OK Band NiCrMo3*	*2nd layer on mild steel												
EN 18274: S Ni6625 (NiCr22Mo9Nb) AWS/SFH 5.14 ER NiCrMo-3	0.01	0.2	1.1	21	Bal.	8	0.026	Nb+Ta=2.8 Fe=4					
With OK Band NiCr3*	*2nd layer on mild steel												
EN 18274: S Ni6082 (NiCr20Mn3Nb) AWS/SFH 5.14 ERNiCr-3	0.02	0.5	3	20	Bal.			Nb=2.5					

OK Flux 10.16 is an agglomerated, non-alloying flux for submerged arc welding specially designed for butt welding with nickel-based alloyed wire. Can also be used for overlay welding with Ni-based strips. The well-balanced flux composition minimises silicon transfer from the flux to the welding metal, provides good mechanical properties, particularly good impact properties, and reduces the risk of hot cracking. OK Flux 10.16 can only be used on DC when butt welding with nickel-based alloy wires. Has also good weldability in the 2G position. Single layer and multi-layer welding of unlimited plate thickness. Flux is suitable for strip cladding with all grades of Ni based strips. For chemical and petrochemical plants, offshore constructions, marine equipment, pressure vessels, storage tanks, etc.

OK Flux 10.90

Basicity index
1.7

Density
~ 1.0 kg/dm³

Grain size
0.25-1.6mm

Slag type
Basic

Polarity
DC+

Alloy transfer
Cr compensating, Ni and Mn alloying

Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
	C	Si	Mn	Cr	Ni	Mo	N	Other	FN	$R_{p\,0.2}$ (MPa)	Rm (MPa)	A4/A5 (%)	CVN (°C/J)
EN 760: SA AF 2 CrNi DC													
With OK Autrod 19.81													
EN 18274: S Ni6059 (NiCr23Mo16) AWS/SFA 5.14 ERNiCrMo-13 DNV: NV5Ni/NV8Ni	0.01	0.2	3	22	Bal.	14.0		Fe=3	5-10	470	675	46	+20/65 -196/70
With OK Autrod 19.82													
EN 18274: S Ni6625 (NiCr22Mo9Nb) AWS/SFA 5.14 ER NiCrMo-3	0.01	0.2	1.5	21	Bal.	8.5		Nb+Ta=3, Fe=3		440	720	33	+20/130 -196/90
With OK Autrod 19.83													
EN 18274: S Ni 6276 (NiCr15Mo16Fe6W4) AWS/SFA 5.14 NiCrMo-4	0.01	0.2	1.9	15	Bal.	14		W=3.5, Fe=7		480	700	35	+20/85 -196/75
With OK Autrod 19.85													
EN 18274: S Ni6082 (NiCr20Mn3Nb) AWS/SFA 5.14 ERNiCr-3	0.01	0.5	3.5	20	Bal.	0.5		Nb=2.5		400	600	35	

OK Flux 10.90 is an agglomerated fluoride basic flux for the submerged arc welding of 9 % Ni steels, other high alloyed steels and Ni-based alloys, using Ni-based wires. OK Flux 10.90 is the answer to your LNG welding problems. Flux is chromium compensating, manganese and slightly nickel adding, thereby minimising the risk of hot cracking when welding with nickel-based alloys. Primarily for multi-run welding. The low Si addition during welding provides good mechanical properties, particularly good impact properties. Has good slag detachability and nice bead appearance and also very good weldability in the 2G position. Works very well on DC current. Single and multi-layer welding of unlimited plate thickness. For chemical and petrochemical plants, offshore constructions, pressure vessels, storage tanks, etc.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Flux 10.92		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**	**Others**	**$R_{p\ 0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
Basicity index 1.0	EN 760: SA CS 2 DC													
	With OK Autrod 308L													
Density ~ 1.0 kg/dm³	EN 12072: S 19 9 L AWS/SFA 5.9: ER308	<0.03	0.9	1	20.0	10.0					365	580	38	-60/60 -196/50
	TÜV													
Grain size 0.25-1.6mm	**With OK Autrod 347**													
	EN 12072: S 19 9 Nb AWS/SFA 5.9: ER347	0.04	0.7	0.9	19.8	9.7			9		470	640	35	+20/65 -60/55 -110/40
Slag type Neutral	TÜV													
	With OK Autrod 316L													
Polarity DC+	EN 12072: S 19 12 3 L AWS/SFA 5.9: ER316L	0.02	0,8	1	19.1	11.9	2.7				385	590	36	-60/55
	TÜV													
Alloy transfer **Cr compen-sating**	**With OK Autrod 318**													
	EN 12072: S 19 12 3 Nb AWS/SFA 5.9: ER318	<0.03	0.5	1.2	18.5	12	2.6		9	Nb=0.5	440	600	42	+20/100 -60/90 -110/40
	TÜV													
	With OK Autrod 309MoL													
	EN 12072: S 23 12 L AWS/SFA 5.9: (ER309MoL)	0.02	0.8	1.5	21	15	3				400	600	38	+20/120
	TÜV													
	With OK Band 308L*	* 3rd layer on 2.5Cr1Mo steel												
	EN 12072: S 19 9 L AWS/SFA 5.9: EQ308L	0.02	1	0.7	20.6	9.8			12					
	TÜV													
	With OK Band 347*	* 3rd layer on 2.5Cr1Mo steel												
	EN 12072: S 19 9 Nb AWS/SFA 5.9: EQ347	0.02	1.3	0.7	20.6	9.5			15	Nb=0.5				
	TÜV													
	With OK Band 316L*	* 3rd layer on 2.5Cr1Mo steel												
	EN 12072: S 19 12 3 L AWS/SFA 5.9: EQ316L	0.02	0.9	0.7	18.5	12.3	2.8		8					
	TÜV													

OK Flux 10.92 is a neutral, agglomerated Cr-compensating flux designed for strip cladding, butt and fillet welding of stainless and corrosion resistant steel types with AWS ER300 type of wires. Works well on DC current for single and multi-layer welding of unlimited plate thickness. Good welding characteristics and easy slag removal. If used for strip cladding with austenitic stainless welding strips, OK Flux 10.92 gives a smooth bead appearance. For chemical and petrochemical plants, offshore constructions, pressure vessels, storage tanks, chemical tankers, power generation, nuclear, pulp and paper, civil constructions, transport industries, etc.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Flux 10.93		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**FN**	**Others**	**$R_{p\ 0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
Basicity index 1.7	EN 760: SA AF 2 DCC													
	With OK Autrod 308L													
Density ~ 1.1 kg/dm³	EN 12072: S 19 9 L AWS/SFA 5.9: ER308L	<0.03	0.6	1.4	20	10		0.06	8		400	560	38	+20/100 -60/65 -110/55 -196/40
Grain size 0.25-1.6mm	DNV 308L, TÜV, DB, CE													
	With OK Autrod 308H													
Slag type Basic	EN 12072: S 19 9 H AWS/SFA 5.9: ER308H	0.05	0.6	1.5	20	9.6			10					
	With OK OK Autrod 347													
Polarity DC+	EN 12072: S 19 9 Nb AWS/SFA 5.9: ER347	0.04	0.5	1.1	19	9.6			8	Nb=0.5	455	635	35	-60/85 -110/60 -196/30
Alloy transfer none	TÜV, DB													
	With OK Autrod 316L													
	EN 12072: S 19 12 3 L AWS/SFA 5.9: ER316L	<0.03	0.6	1.4	18.5	11.5	2.7		8		390	565	35	-60/90 -110/75 -196/40
	DNV 316L, TÜV, DB													
	With OK Autrod 317L													
	EN 12072: S 18 15 3 L AWS/SFA 5.9: ER317L	<0.04	0.6	1.5	19	13.5	3.5				440	615	28	+20/80 -60/50
	With OK Autrod 316H													
	EN 12072: S 19 12 3 H AWS/SFA 5.9: ER316H	0.05	0.6	1.5	18.5	11.5	2.7							
	With OK Autrod 16.38													
	EN 12072: S 20 16 3 Mn L RINA N50M	0.02	0.7	5.4	20	15.5	2.5	0.13	0		410	600	44	-60/70 -110/60 -196/40
	With OK Autrod 318													
	EN 12072: S 19 12 3 Nb AWS/SFA 5.9: ER318 TÜV, DB	<0.04	0.6	1.2	18.5	12	2.6		9	Nb=0.5	440	600	42	+20/100 -60/90 -110/40
	With OK Autrod 309L													
	EN 12072: S 23 12 L AWS/SFA 5.9: ER309L	<0.03	0.6	1.5	24	12.5					430	570	33	+20/90 -60/70 -110/60 -196/35
	DNV 309L, LR, TÜV, CE													
	With OK Autrod 309MoL													
	EN 12072: S 23 12 L AWS/SFA 5.9: (ER309MoL)	0.02	0.5	1.5	21	15	3				400	600	38	+20/120
	With OK Autrod 385													
	EN 12072: S 20 25 5 Cu L AWS/SFA 5.9: ER385	<0.03	0.6	1.5	19	25	4			Cu=1.5	310	530	35	+20/80 -196/35
	TÜV													
	With OK Autrod 310													
	EN 12072: S 25 20 AWS/SFA 5.9: ER310	0.10	0.5	1.1	26	21					390	590	45	+20/170
	With OK Autrod 312													
	EN 12072: S 29 9 AWS/SFA 5.9: ER312	0.10	0.5	1.5	29.0	9.5					530	750	20	
	With OK Autrod 2209													
	EN 12072: S 22 9 3 N L AWS/SFA 5.9: ER2209	<0.025	0.8	1.3	22	9	3	0.15	45		630	780	30	+20/140 -60/110 -110/80
	ABS, BV, DNV, GL, LR, TÜV, RINA													
	With OK Autrod 310MoL													
	EN 12072: S 25 22 2 N L AWS/SFA 5.9: (ER310MoL)	0.02	0.1	4	24.5	22	2.1	0.12			335	575	42	+20/120
	With OK Autrod 2509													
	EN 12072: S 25 9 4 N L	<0.03	0.5	0.6	24.5	9.5	3.5	0.15	40		640	840	28	+20/85
	TÜV													
	With OK Autrod 16.97													
	EN 12072: S 18 8 Mn AWS/SFA 5.9: (ER307)	0.06	1.2	6.3	18.0	18					400	600	45	+20/95 -110/40
	DNV													

OK Flux 10.93 is an agglomerated basic flux for the submerged arc welding of stainless steels, primarily multi-run. Designed for the butt and fillet welding of standard austenitic stainless steels and higher alloyed stainless steels. The low Si addition during welding provides good mechanical properties, particularly good impact properties. Has also very good weldability in the 2G position. Works very well on DC current. Single and multi-layer welding of unlimited plate thickness. The slag is self lifting or easily detached leaving clean and flat welds with good penetration. For chemical and petrochemical plants, offshore constructions, pressure vessels, storage tanks, chemical tankers, power generation, nuclear, pulp and paper, civil constructions, transport industries, etc. A flux specially suitable for joining duplex 2205 stainless steels, e.g. in chemical tankers.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Flux 10.94		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
Basicity index 1.7	EN 760: SA AF 2 Cr DC													
	With OK Autrod 308L													
Density ~ 1.0 kg/dm³	EN 12072: S 19 9 L AWS/SFA 5.9: ER308L	0.02	0.5	1.4	20.2	9.7		0.06		11	400	560	40	+20/85 -60/60
	With OK Autrod 347													
Grain size 0.25-1.6mm	EN 12072: S 19 9 Nb AWS/SFA 5.9: ER347	0.04	0.5	1.0	19.6	9.6			Nb=0.5	9	455	620	38	+20/100 -60/70 -110/50 -196/30
Slag type Basic														
	With OK Autrod 316L													
Polarity DC+	EN 12072: S 19 12 3 L AWS/SFA 5.9: ER316L	0.02	0.6	1.2	19.5	11.5	2.7				430	570	36	+20/80 -196/35
	With OK Autrod 2509													
Alloy transfer Cr compensating	EN 12072: S 25 9 4 N L	<0.04	0.5	0.5	25.5	9.5	3.5	0.2		50	625	830	28	+20/90 -60/50

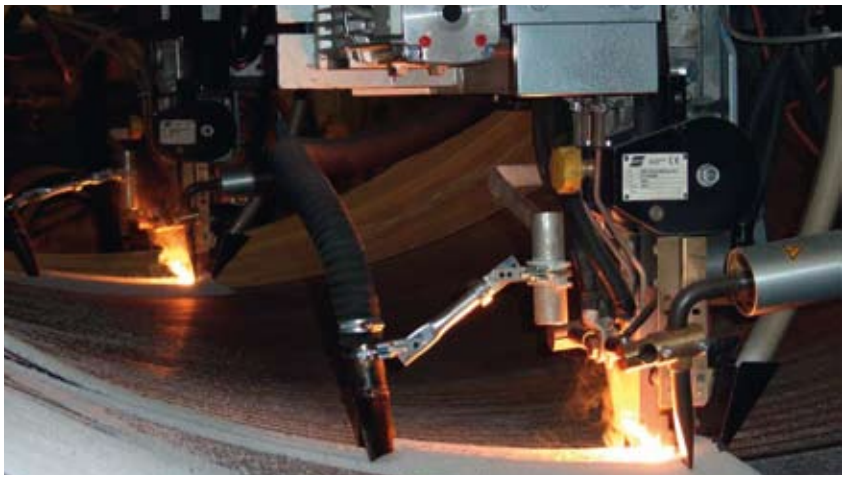
OK Flux 10.94 is a basic, chromium-compensating, agglomerated flux for the butt welding of stainless steels, primarily multi-run. Low Si addition during welding provides good mechanical properties. Works well on DC current. Single and multi-layer welding of unlimited plate thickness. The slag is self lifting or easily detached, leaving clean and flat welds.
For chemical and petrochemical plants, pressure vessels, storage tanks, chemical tankers, etc. Specially recommended for joining-super duplex 2507 stainless steels, e.g. in offshore applications.

	Classifications & approvals	Typical chemical composition all weld metal (%)									Typical mechanical properties all weld metal			
OK Flux 10.95		**C**	**Si**	**Mn**	**Cr**	**Ni**	**Mo**	**N**	**Other**	**FN**	**$R_{p\,0.2}$ (MPa)**	**Rm (MPa)**	**A4/A5 (%)**	**CVN (°C/J)**
Basicity index 1.7	EN 760: SA AF 2 Ni DC													
	With OK Autrod 308L													
Density ~ 1.0 kg/dm3	EN 12072: S 19 9 L AWS/SFA 5.9: ER308L	<0.03	0.6	1.4	20.0	11.0		0.06		3	400	540	40	+20/88 -60/80 -110/70 -196/50
Grain size 0.25-1.6mm	**With OK Autrod 308H**													
	EN 12072: S 19 9 H AWS/SFA 5.9: ER308H	<0.08	0.4	1.8	20.5	10.0		0.05		8	270	520	55	
Slag type Basic	**With OK Autrod 347**													
Polarity DC+	EN 12072: S 19 9 Nb AWS/SFA 5.9: ER347	0.04	0.5	1.0	19.0	10.0			Nb=0.5	6	455	620	38	+20/100 -60/70 -110/50 -196/40
Alloy transfer Cr compensating	**With OK Autrod 316L**													
	EN 12072: S 19 12 3 L AWS/SFA 5.9: ER316L	<0.03	0.6	1.4	18.5	11.5	2.7				390	565		-60/50 -110/75 -196/40

OK Flux 10.95 is basic, nickel alloying, agglomerated flux for submerged arc butt and fillet welding of austenitic stainless steels with AWS ER 300 type of wires. A flux specially suitable for applications requiring a lower ferrite content of max. 3-8%. Specially recommended for welding stainless steels when impact strength at low temperatures is required. Primarily for multi-run welding. Works very well on DC current. The weld beads produced with OK Flux 10.95 provide neat weld surfaces, very good welding properties and easy slag removal. For chemical and petrochemical plants, offshore constructions, pressure vessels, storage tanks, civil constructions, transport industries, etc.

The stainless steel cladding process

Stainless steel strip cladding is a flexible and economical way of depositing a corrosion-resistant, protective layer on a load-bearing mild or low-alloy steel.



Two cladding processes

Submerged arc welding (SAW) is the most frequently used process, but if higher productivity and restricted dilution rates are required, electroslag welding (ESW) is recommended. Both proceses are characterised by a high deposition rate and low dilution. They are suitable for surfacing flat and curved objects such as heat exchanger tube sheets or pressure vessels of different kinds.

SAW strip cladding

The well-known SAW method has been widely used with strip electrodes since the mid-1960s. A strip electrode, normally measuring 60 x 0.5 mm or 90 x 0.5 mm, is used as the (usually positive) electrode and an electric arc is formed between the strip and the workpiece. Flux is used to form a molten slag to protect the weld pool from the atmosphere and helps to form a smooth weld bead surface.

ESW strip cladding

Electroslag strip cladding, which is a further development of submerged arc strip cladding, has quickly established itself as a reliable high deposition rate process. ESW strip cladding relates to the resistance welding processes and is based on the ohmic resistance heating in a shallow layer of liquid electroconductive slag. The heat generated by the molten slag pool melts the surface of the base material and the strip electrode end, which is dipping in the slag and the flux. The penetration is less for ESW than for SAW since there is no arc between the strip electrode and the parent material.

Fluxes for ESW strip cladding are high basic, with a high share of fluorides. To increase the cladding speed at corresponding high welding currents, it is necessary to use fluxes producing a slag of even higher electrical conductivity and lower viscosity.

ESW features

Compared to submerged arc strip cladding the electroslag cladding process shows the following features:

- Increased deposition rate by 60% to 80%.
- Only half of the dilution from the base material due to less penetration (about 10-15% dilution).
- Lower arc voltage (24–26 V).
- Higher amperage and current density (about 1000–1250 A with strips of 60 mm width, corresponding to 33–42 A/mm^2). Specially developed fluxes for high productivity purposes can be welded with amperage in excess of 2000 A which corresponds to a current density about 70 A/mm^2.
- Increased welding speed (50%–200% higher), resulting in a higher area coverage in m^2/h.
- Comparable heat input.
- Lower flux consumption (about 0.4-0.5 kg/kg strip).
- The solidification rate of the ESW weld metal is lower, improving the degasification and the resistance to porosity. Oxides can rise easier out of the molten pool to the surface; the overlay metal is cleaner from a metallurgical point of view and thus less sensitive to hot cracking and corrosion.

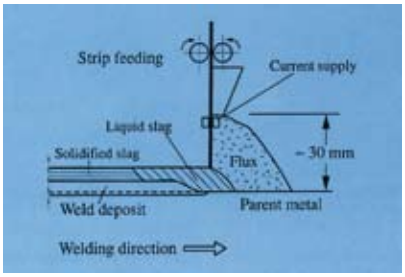


Figure 1.Principles of electroslag strip cladding.

Facts about stainless steels

The large and steadily growing family of stainless steels can offer unique combinations of corrosion resistance and properties.

“Stainlessness”

”Stainless” is a term coined, early in the development of these steels for cutlery products. It was adopted as a generic name and, now, covers a wide range of steel types and grades for corrosion or oxidation resistant applications.

Stainless steels owe their corrosion resistance to the presence of a ”passive”, chromium-rich, oxide film that forms naturally on the surface. Although extremely thin and invisible, this protective film adheres firmly, and is chemically stable under conditions which provide sufficient oxygen to the surface. Furthermore, the protective oxide film is self-healing provided there is sufficient oxygen available. Therefore, even when the steel is scratched, dented or cut, oxygen from the air immediately combines with the chromium to reform the protective layer. As an example, over a period of years, a stainless steel knife can literally be worn away by daily use and by being re-sharpened – but remains stainless.

Families of stainless steels

It is fortunate that corrosion resistance can be obtained in an iron-based system simply by the addition of chromium, since, by appropriate adjustment of other alloying elements such as nickel and carbon, a wide range of microstructures can be developed. Hence, stainless steels can offer a remarkable range of mechanical properties and corrosion resistance and are produced

Table 1. Main stainless steel types.

Stainless Steel Type	Chemical composition (%)		Applications
	Standard grades	Special grades	
Ferritic	<0.08 C* 10.5-19 Cr 0-2.5 Ni 0-2.5 Mo + Ti, Nb	- increased Cr, Mo, - extra low C and N (ELI)	Household machines, automotive parts, chemical industry
Martensitic	0.1-0.5 C 11-17 Cr 0-2.5 Ni 0-1 Mo	- increased Ni, Mo, C - very low C for weldability, - sometimes Nb, Ti, V - precipitation hardening with e.g. Cu, Al	Tools and machine parts, oil & gas industry, chemical industry, hydropower applications
Austenitic	<0.08 C* (typically <0.03 C) 16-19 Cr 6-16 Ni 0-5 Mo	- increased Cr,Mo, Ni, - stabilisation with Nb, Ti, - sometimes Cu, N - improveded machinability with S	Equipment, vessels and pipelines within chemical, food, power, oil, gas, pulp and paper industries.
Duplex (Austenitic-Ferritic)	<0.03 C* 18-30 Cr 1.5-8 Ni 1-5 Mn 0-4 Mo 0.1-0.3 N	- increased Cr, Mo, N - sometimes Cu, W	Oil, gas, chemical industry, pulp and paper industries, heat exchangers, chemical tankers.

*** typically higher C-content in creep and heat resistant grades**

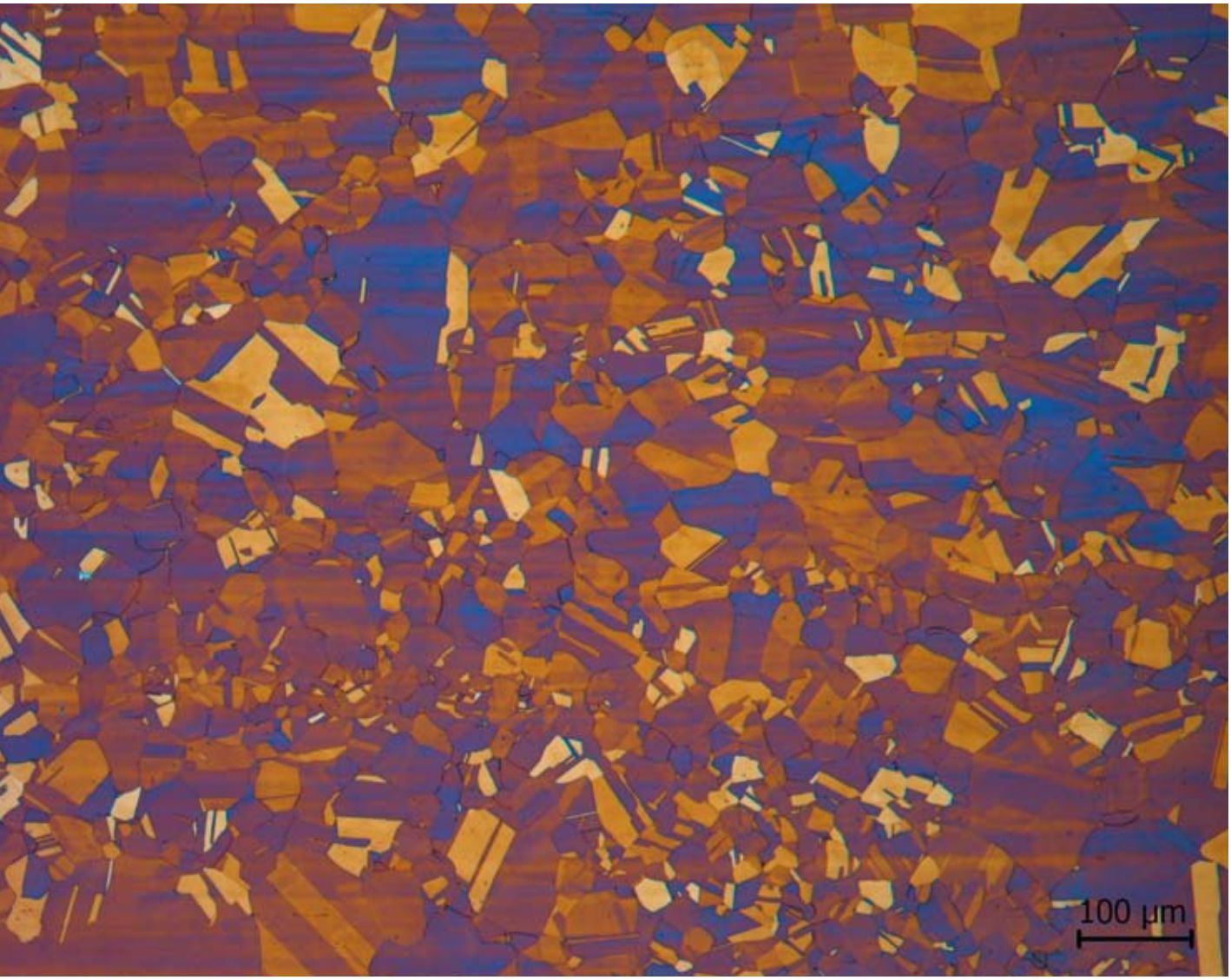
in numerous grades. Properties such as corrosion resistance, formability, weldability, strength and cryogenic toughness are largely determined by the microstructure. Stainless steels are therefore typically classified into a number of general groups according to their microstructure. The major families of stainless steel are listed in table 1.

Super-austenitic or super-duplex grades have enhanced pitting and crevice corrosion resistance compared with the ordinary austenitic or duplex types. This is thanks to further additions of chromium, molybdenum and nitrogen. Super-martensitic steels have a very low carbon content improving weldability greatly. Heat and creep resistant versions of many steels are also available. These have a slightly modified composition and when intended for creep applications in particular a somewhat higher carbon content.

Properties and weldability

Ferritic stainless steels

Ferritic stainless steels have properties similar to mild steels but with better corrosion resistance, due to the addition of typically 11-17% chromium. They are comparatively inexpensive due to their low Ni-content and have good resistance to chloride stress corrosion cracking. The more highly alloyed grades, in particular, show poor toughness at low temperatures and are prone to embrittlement at high temperatures.



Weldability of ferritic stainless steel varies depending upon the composition. Modern grades with controlled martensite formation and limited carbide precipitation in the heat affected zone (HAZ). are reasonably weldable. However, all ferritic stainless steels suffer from grain growth in the HAZ resulting in loss of toughness. Consequently, interpass temperature and heat input must be limited. Preheating is sometimes required to prevent cracking during cooling for thicknesses above 3 mm for grades forming some martensite.

Consumables for the welding of ferritic stainless steels can be ferritic with a composition matching the parent metal or austenitic. Ferritic stainless steels are resistant to corrosion in sulphur containing atmospheres. The use of austenitic consumables is not recommended for this kind of application.

Martensitic stainless steels

Martensitic grades can be hardened by quenching and tempering, like plain carbon steels. They have moderate corrosion resistance and contain, typically, 11-13% chromium with a higher carbon content than ferritic grades. Martensitic stainless steels are used because of their mechanical strength, hardness and corrosion resistance. The strength of precipitation hardening grades can be increased further through special heat treatments. The toughness of martensitic stainless steel is limited and decreases with increasing carbon content. However, martensitic-austenitic grades, alloyed with significant amounts of nickel, have improved toughness and weldability. Supermartensitic stainless steels with very low carbon content, improving corrosion resistance and weldability, have recently been introduced.
Weldability is comparatively poor, and becomes worse with increasing carbon content, as there is always a hard and brittle zone in the parent metal adjacent to the weld. Preheating, welding with a well-controlled minimum interpass temperature followed by cooling, tempering and finally slow cooling is therefore normally required. If this is ignored, there is a significant risk of cold cracking in the hard and brittle HAZ region. Martensitic-austenitic and supermartensitic grades require less or no preheating and PWHT.

Matching composition martensitic consumables are used when weld metal properties need to match those of the parent material. However, austenitic consumables are typically preferred as they decrease the risk of cracking. When complicated structures are to be welded a buttering technique can be used. The groove faces are then covered with austenitic filler metal and heat treated as necessary to restore HAZ toughness. The buttered layer is thick enough to ensure no structural change occurs in the parent metal when completing the joint.

Austenitic stainless steels

Austenitic stainless steels have a nickel content of at least 6% to stabilise the structure and provide ductility, a large range of service temperatures, non-magnetic properties and good weldability. This is the most widely used group of stainless steels found in numerous applications. A large number of steel grades have been developed starting from the classical base composition 18%Cr/8%Ni.

Some commonly used variants are those which contain Mo to provide improved pitting corrosion resistance, those with Nb or Ti to stabilise against Cr-carbide precipitation causing intergranular corrosion and higher strength N-alloyed grades. Corrosion resistance is very good to excellent, depending on alloying content and environment.
In particular the level of Cr-, Mo- and N-alloying has a large effect on corrosion resistance with the most highly alloyed grades usually termed superaustenitic. A further division into e.g. standard, stabilised, fully austenitic, nitrogen alloyed, heat resistant grades and steels with improved machinability is common.

Austenitic stainless steels have in most cases excellent weldability and any of the main welding processes can be applied. They are not hardenable, but excessive heat input and preheating should be avoided to minimise the risk of hot cracking, distortion and for non-stabilised grades with carbon levels above about 0.03% also to avoid sensitisation to intergranular corrosion. Precipitation of intermetallic phases can occur in the more highly alloyed grades.

Austenitic stainless steels are welded with consumables with a similar or over-alloyed chemical composition with respect to the parent metal. Over-alloying is required for the more highly alloyed grades to optimise corrosion resistance by compensating for segregation effects in the weld metal. Highly alloyed nickel-based consumables are generally used for superaustenitic steels.

The steels are normally supplied with a single-phase austenitic structure. However, during welding ferrite can form in the weld metal and in the HAZ. Ferrite can affect properties and weldability in a number of ways as described in more detail in "Ferrite in weld metals". On the positive side ferrite tends to prevent hot cracking, something which is more of a problem with fully austenitic stainless steels and weld metals. On the negative side ferrite can be selectively attacked in some environments and can easier than austenite transform into sigma phase at high temperatures. Filler metals for the welding of standard austenitic stainless steels are therefore generally designed to form some ferrite in the weld metal. In applications where a fully austenitic weld deposit is required hot cracking can be avoided by alloying the filler metal with Mn.

Duplex (Austenitic-Ferritic)

stainless steels

Duplex stainless steels have a mixed structure with approximately equal proportions of ferrite and austenite, hence the term "duplex". They are alloyed with a combination of nickel and nitrogen to produce a partially austenitic lattice structure and improve mechanical properties and corrosion resistance. There is a wide range of duplex grades all offering an attractive combination of high strength and good corrosion resistance. Having grown to a large family, the duplex stainless steels now range from the lean grades, that are cost efficient and compete with the standard austenitic grades, to the highly alloyed superduplex grades for more demanding applications

Generally, duplex stainless steels have good weldability and can be welded using a wide range of techniques. Welding consumables are of the duplex type but typically slightly different in composition compared to the corresponding steel grade. In particular they need to be higher in elements promoting austenite formation, usually Ni, to avoid excessively high weld metal ferrite contents that otherwise impair properties. Welding without filler metal is therefore usually not recommended. Preheat is not necessary but the heat input has to be within certain limits depending on grade. Too low a heat input leads to a high cooling rate and high ferrite levels. On the other hand, too high a heat input can result in precipitation of deleterious phases in particular in the highly alloyed superduplex grades. In both cases toughness and corrosion resistance will suffer.

Literature

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Corrosion

Stainless steels

A very thin layer of chromium-rich oxide film, which is formed spontaneously on the surface in the presence of oxygen, protects stainless steels against corrosion. However, stainless steels cannot be considered to be ”indestructible”. The passive state can be broken down under certain conditions and corrosion can result as briefly discussed below. It is therefore important to carefully select the appropriate grade for a particular application. Effects of welding and handling on corrosion resistance also have to be considered.

Uniform corrosion

This is a type corrosion that proceeds at more or less the same velocity over the entire surface. Attack by uniform corrosion occurs mainly in acids or in strongly alkaline solutions. The resistance against uniform corrosion is typically improved by increasing the content of Cr and Mo in the steel.

Intergranular corrosion

A localised attack at and adjacent to the grain boundaries is called intergranular corrosion. Stainless steels can become sensitive to intergranular corrosion when exposed to elevated temperatures (500-850°C). Local consumption of Cr at the grain boundaries by carbide precipitation then results in depleted regions with inferior corrosion resistance. Precipitation of chromium carbides can be prevented either by a low C-content or by adding stabilising elements like Nb or Ti.

Pitting corrosion

This is a type of localised corrosion, which is highly destructive, ultimately resulting in holes. Pitting attack in stainless steel is most common in neutral or acidic chloride containing environments. The resistance against pitting improves with increasing Cr-, Mo- and N-contents. A Pitting Resistance Equivalent, PREN,

is commonly used to qualitative compare the pitting resistance of different alloys:

PREN = %Cr + 3.3 %Mo + 16%N.

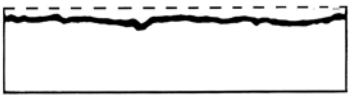
Care should be taken, though, when comparing steels and weld metals since the inevitable segregation of alloying elements occurring during solidification makes weld metals less resistant for comparable compositions.

Crevice corrosion

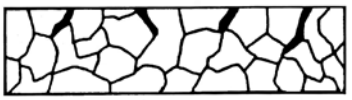
Crevice corrosion is a kind of localised corrosion,
which occurs, in narrow crevices under the same
conditions as pitting. However, corrosion attacks initiates and propagates more easily in a crevice filled with a liquid, where the oxygen needed to maintain the passive layer quickly is consumed. Typical examples are under gasket surfaces, lap joints and under bolt and rivet heads. A special form of crevice corrosion is called deposit corrosion. This occurs under non-metallic deposits or coatings on the metal surface. Steels with good resistance to pitting corrosion also have good resistance to crevice corrosion.

Stress corrosion cracking

Stress corrosion cracking (SCC) is caused by the combined effect of tensile stresses and exposure to a corrosive environment. The metal surface can appear virtually unattacked while fine racks propagate through the entire thickness. In particular standard austenitic stainless steels are susceptible to SCC in solutions containing chloride. The risk goes up with increasing concentration, higher tensile stress and increasing temperature. SCC is, however, seldom found in solutions below 60°C. Ferritic and duplex stainless steels are generally very resistant to SCC and increased Ni- and Mo-contents improve the resistance of austenitic grades.



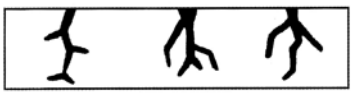
Uniform corrosion



Intergranular corrosion

Pitting corrosion

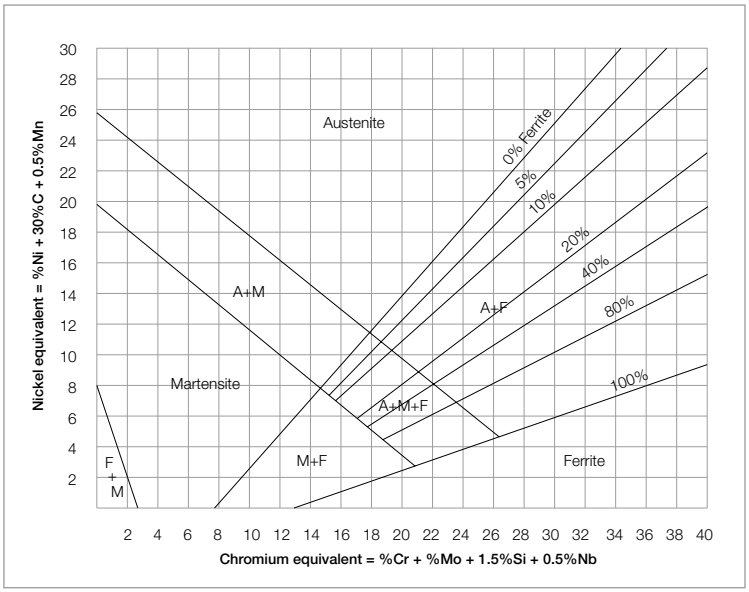
Crevice corrosion



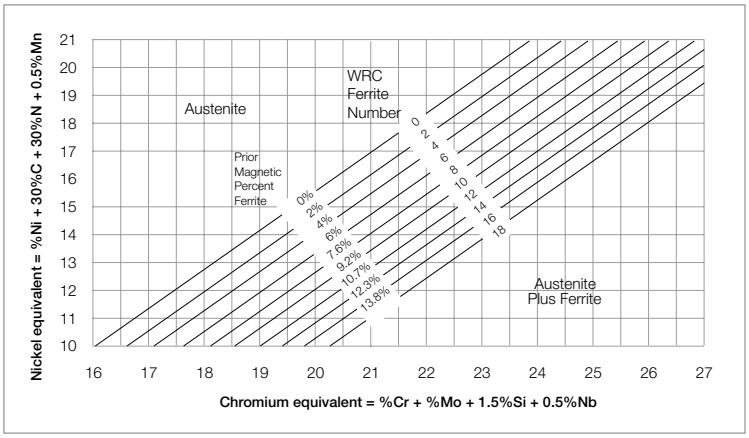
Stress corrosion cracking

Ferrite in weld metals

Ferrite is obviously a major constituent in ferritic and duplex weld metals. Some ferrite can often also be found in martensitic and in particular in a majority of austenitic weld metals.
The weld metal ferrite content can influence a wide range of properties, including corrosion resistance, toughness, long term high temperature stability, resistance to hot cracking etc. Austenite is tougher and more ductile than ferrite, especially at low temperatures, it is not ferromagnetic and less likely to form brittle phases at elevated temperatures. On the other hand, ferrite is highly resistant to stress corrosion cracking, it is ferromagnetic and usually has a higher yield strength than austenite.



The Schaeffler Diagram



The DeLong Diagram

An important aspect of ferrite in weld metals is related to the solidification behaviour. It is widely accepted that welds which initially solidify as austenite are more susceptible to hot cracking than those that initially solidify as ferrite. This is largely due to the greater solubility of ferrite for alloying and impurity elements that promote hot cracking.
Most welds, including standard austenitic types such as 308 and 316, are therefore designed to solidify primarily as ferrite to improve hot cracking resistance. This means that the austenite is mainly formed when the initial ferrite is transformed during cooling. Consequently, the ferrite content at room temperature is not the same as during solidification and will depend on cooling rate.

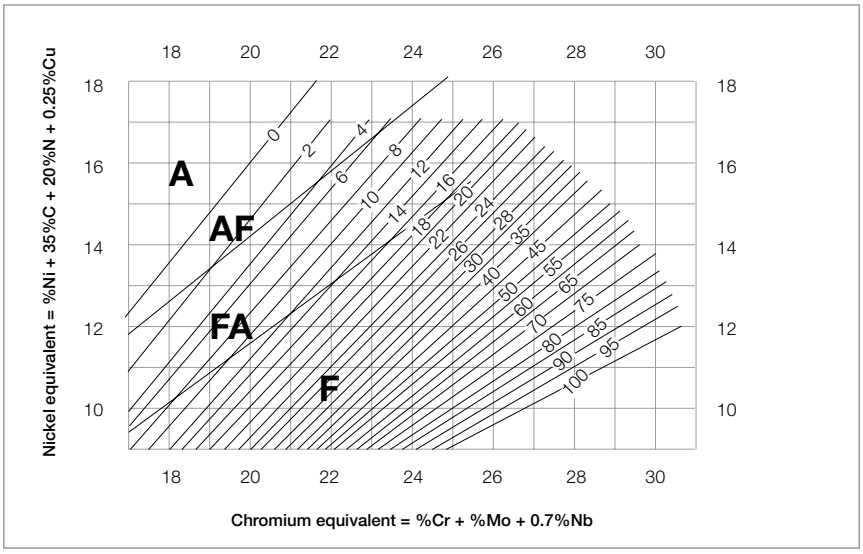
Measurement and prediction of ferrite content

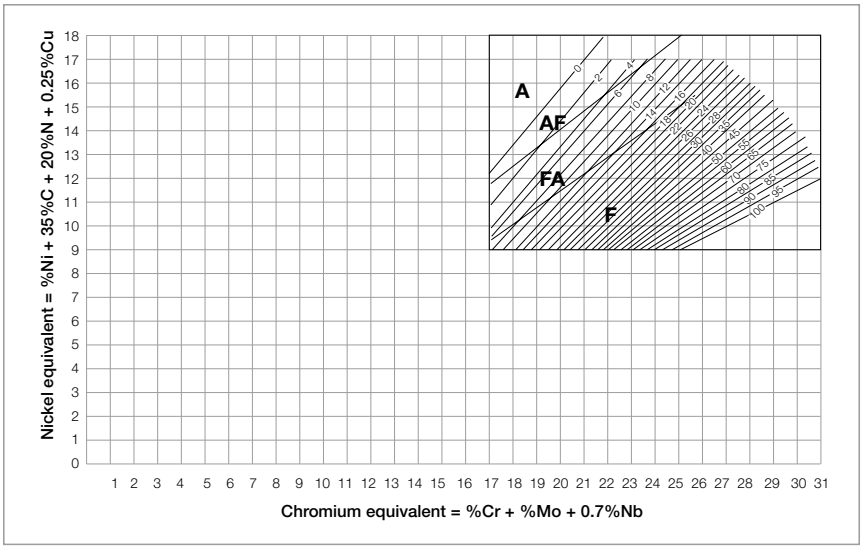
Ferrite determination is frequently required for weld procedure qualification and also commonly specified for filler metals. The ferrite content can either be measured by point counting techniques, magnetic methods or it can be predicted based on the chemical composition of the weld metal.

Measuring the ferrite content

There are two types of methods for measuring the ferrite content of weld metals and parent materials: (a) point counting techniques and (b) magnetic methods.

Point counting gives a ferrite content in ferrite percentage (sometimes denominated FP). Magnetic methods takes advantage of the





the WRC-1992 diagram (see Figures Z and W

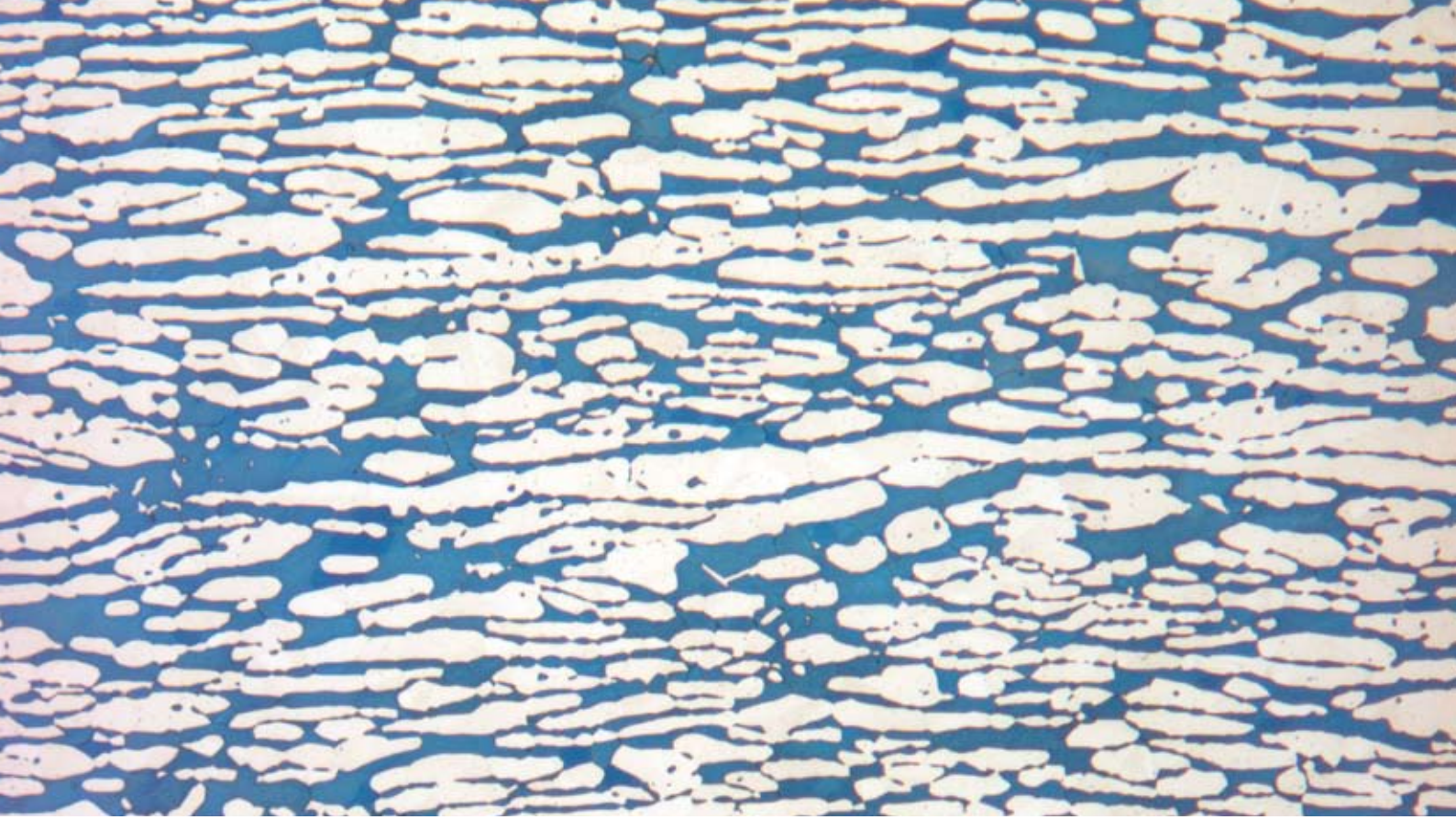
different magnetic properties of ferrite and austenite with ferrite being ferro-magnetic, whilst austenite is not. A Ferrite Number (FN) is assigned to a given level of magnetic attraction, defined from primary standards using a magnetic beam balance known commercially as a MagneGage instrument. It is important to realise that there is no unique correlation of Ferrite Number with ferrite percentage since the FN depends not only on the ferrite percentage but also on composition. The Ferrite Number is approximately equivalent to the percentage ferrite at low values but will be larger than the percentage ferrite at higher values.

a) Point counting involves direct microscopic measurement on suitably prepared specimens and gives the ferrite content in ferrite percentage. This is a destructive method since a polished and etched metallographic section is required. It cannot therefore readily be used on completed welded fabrications, but can be used on representative welding procedure samples. The main advantage of the point counting technique is that it can be applied to all microstructures, including the narrow HAZ. Point counting is, however, relatively slow and labour intensive. Comparative studies have also shown a great deal of scatter between different laboratories and different operators.

b) Instruments for magnetic measurements of ferrite content in Ferrite Number (FN) are based on one of two principles. They make either use of a permanent magnet and measure tearing-off force (e.g., a MagneGage) or utilise eddy current to measure magnetic properties (e.g., Fisher Feritscope). Both methods are in principle non-destructive although use of the MagneGage requires a flat polished specimen and is less suitable for field application. However, hand held equipment based on eddy current techniques is available and can be used on welds with a minimum of surface preparation. All magnetic methods require the use of appropriate primary standards (permanent magnet principle) or secondary standards (eddy current techniques) in order to calibrate the equipment and enable accurate measurements of FN to be made.

Predicting ferrite content

Prediction of weld metal ferrite content can be carried out based on the chemical composition of the weld metal. A number of predictive diagrams are available with the newer diagrams making predictions



in terms of Ferrite Number (FN) instead of ferrite percentage. *The Schaeffler Diagram (see Figure X op p64)*, now more than fifty years old, is well out-dated for ferrite prediction in stainless steel welds and was followed by the DeLong Diagram (see Figure Y op p64) recognising the importance of nitrogen content. The today most widely used predictive diagram, and the one recognised by the ASME code since 1995 is the WRC-1992 diagram (see Figures Z and W op p65). Other systems, including some based on Neural Networks are also available. All these methods depend on an accurate chemical analysis of the actual weld deposit. When certified compositions of the welding consumable are used, it must also be recognised that these will not necessarily be the same as the deposit composition, depending on dilution by parent materials and welding parameters.

Comments

When specifying, measuring or predicting ferrite contents one should be aware of some basic facts:

- The ferrite content of real weldments is affected by a number of factors the most important typically being filler composition, dilution with parent material, nitrogen pickup and cooling rate.
- Ferrite is not homogeneously distributed within a weld. For example, the ferrite content is generally lower at the interface between two weld passes since heating by deposition of the subsequent adjacent pass causes some ferrite to transform to austenite.
- To require a ferrite range after post-weld heat treatment is in general irrelevant as ferrite transforms to other phases during PWHT.
- Measuring and predicting ferrite content is not an exact science:
  - It is unrealistic to require both a measured and a calculated FN for a given weld metal to be within a narrow range.
  - Chemical analysis includes variability and even the WRC-92 Diagram has a possibility of error on the order of ± 4 FN in the 0-18 FN range.
  - A study involving 17 laboratories in 8 countries organised within the International Institute of Welding indicated that scatter of about ± 20 % of the measured value should be expected between different laboratories when testing real welds.

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Joining of Dissimilar Steels

Different types of stainless steels can normally be welded to one another without difficulty. It is, however, essential that a consumable with at least the same mechanical strength and corrosion resistance as the poorest of the base materials is used and that the recommendations for welding these are followed.

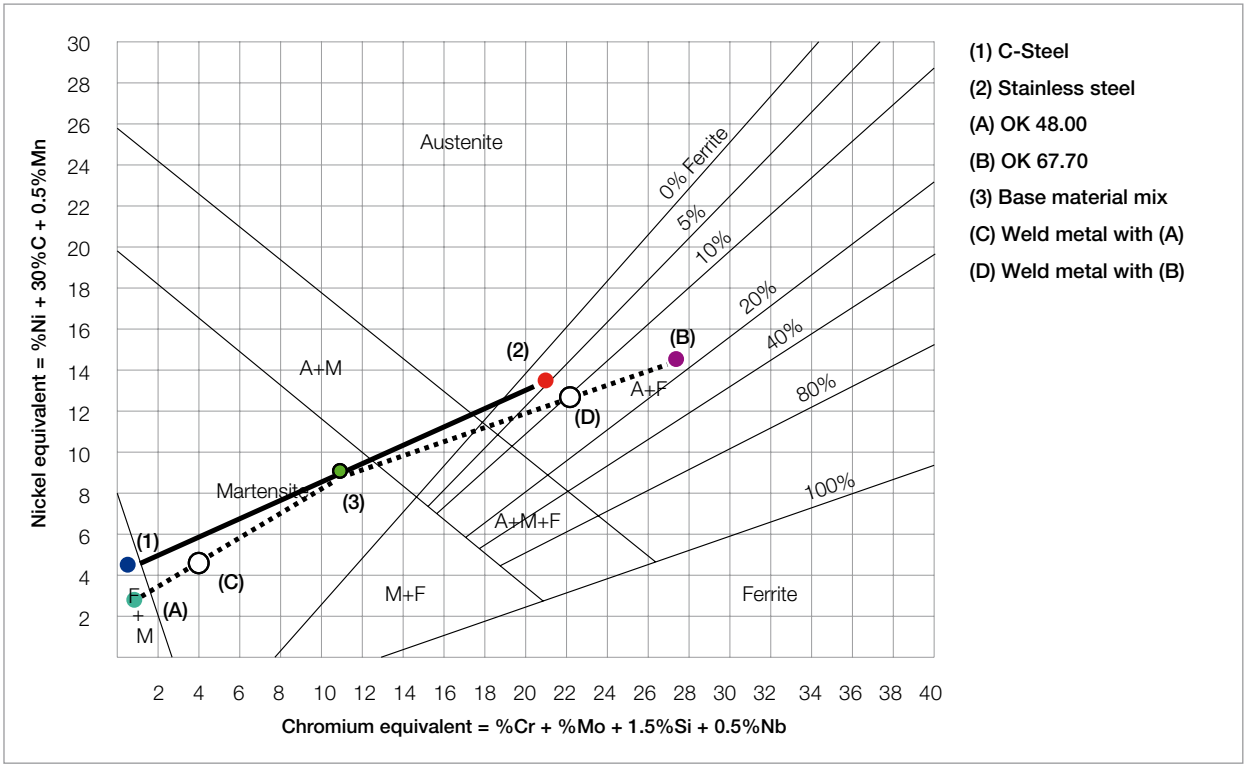
Stainless steels can also be welded to mild or low-alloy steels with excellent results if the steel has a reasonable weldability and if certain straightforward guidelines for the avoidance of cracking are followed. The same basic metallurgical considerations apply also to cladding of mild or low-alloy steels with a stainless layer as well as welding of stainless steel/ mild or low-alloy steel compound material.

The main concern during welding is to avoid cracking in the weld metal and in the base material heat affected zone (HAZ). Cracking can be either hydrogen assisted cracking or hot cracking depending on base and filler metal and on the welding procedure.

Weld metal considerations

The dilution of the filler metal by the base material must be taken into account to avoid the formation of hard and brittle or hot cracking susceptible structures. A mild steel filler metal will result in a highly alloyed brittle martensitic microstructure when deposited on a stainless steel. Using a standard stainless filler metal will usually result in the same unfavourable microstructure when welding on a mild steel. In both cases the hard and brittle regions of the welds are very likely to show extensive cracking.

There are three main approaches to produce sound crack resistant dissimilar welds between stainless and mild or low-alloy steels. Typically the first approach is preferred.
The most common approach is to aim for a weld metal composition giving an austenitic



structure with some ferrite. As discussed in the " Ferrite in weld metals" section this will produce a very crack resistant and ductile weld. Typically overalloyed consumables of the (in wt.%) 23Cr 12Ni (with or without Mo) and 29Cr 9Ni types are used. A duplex filler can in most cases also be used with good result.
A similar but somewhat different approach is to use fillers depositing a more or less fully austenitic weld metal. In this case alloying with relatively high levels of Mn is needed to ensure crack resistance. A common type of filler is 18Cr 8Ni 6Mn.
Ni-base fillers should be used for service temperatures above approximately 350-400ºC to minimise carbon migration into the weld.

A diagramme such as the Schaeffler Diagram or the more recent WRC-1992 Diagram can be used to predict the microstructure of the weld metal. The WRC-1992 Diagram is likely to give a more precise prediction of weld metal ferrite content but the Schaeffler Diagram has the advantage of showing the structure for any steel weld metal composition. An example is presented in the figure on page 86 illustrating the joining of mild steel and 18Cr 12Ni 3Mo type stainless steel.

Example

Prediction of weld metal microstructure of a dissimilar joint between a stainless steel (1: 18Cr 12 3Mo) and a mild steel (2) welded with either an unalloyed consumable (A: OK 48.00) or an overalloyed stainless electrode (B: OK 67.70).

Step1: Calculate Nickel- and Chromium-equivalents from steel and consumable compositions and plot these in the diagram.

Step 2: Connect the two steel compositions with a line.

Step 3: Assume that equal amounts of the base materials will be fused. Mark the position on the line halfway between the two steel compositions (3).

Step 4: Connect the halfway point and the position of the consumable compositions of interest with lines.

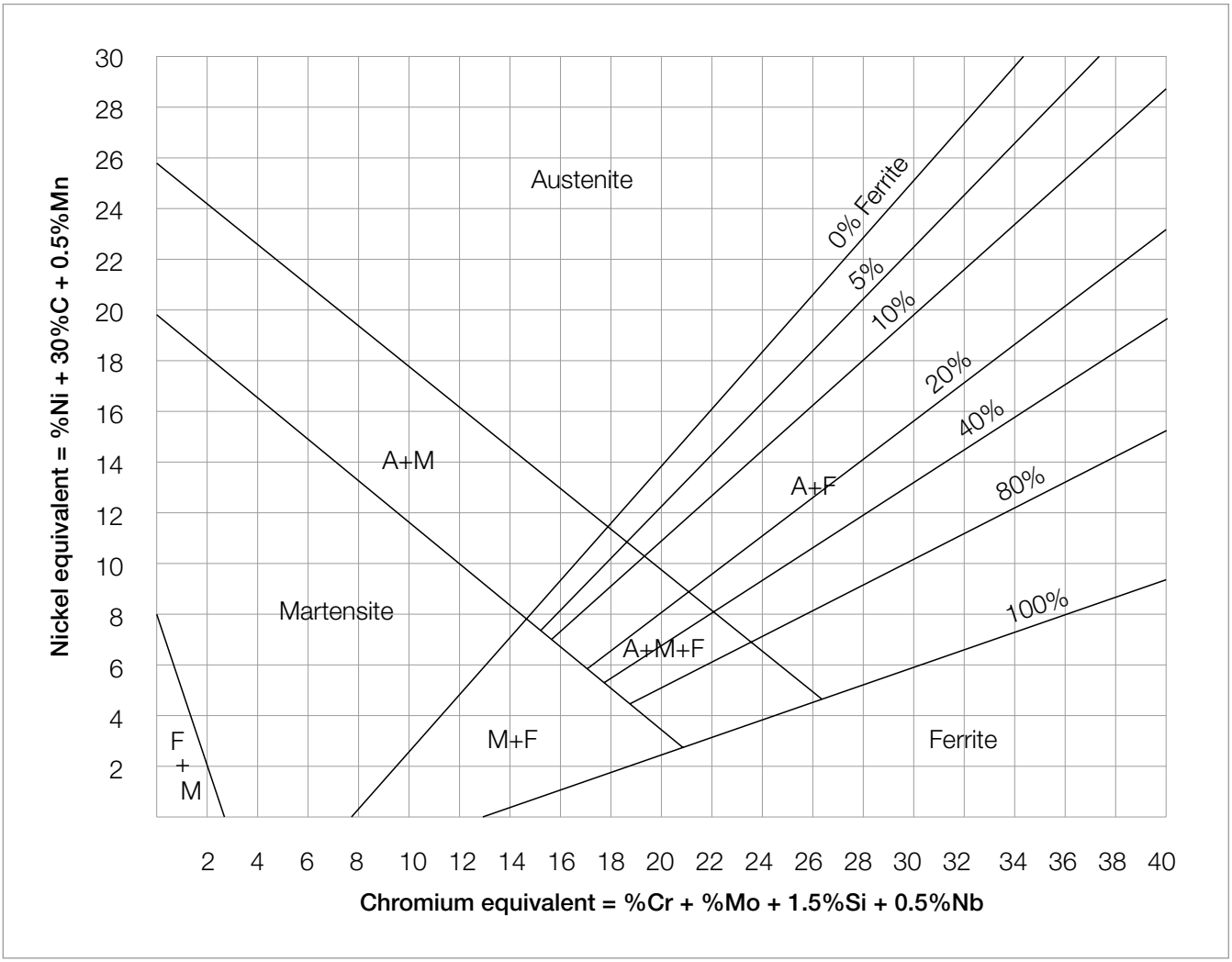
Step 5: The weld metal composition is given by a point located X% of the distance between the halfway point (see step 3) and the consumable composition point. X is the assumed dilution which is typically 25-40 % for MMA, 15-40% for MIG /MAG, 25-100% for TIG and 20-50% for SAW. In this example the dilution level is assumed to be 30%.

The overalloyed stainless consumable will, as shown by the example, give a desired ductile and crack resistant austenitic weld metal with some ferrite (point D). Using an unalloyed consumable will however produce a martensitic weld metal (point C) which is harder, brittle and likely to crack.

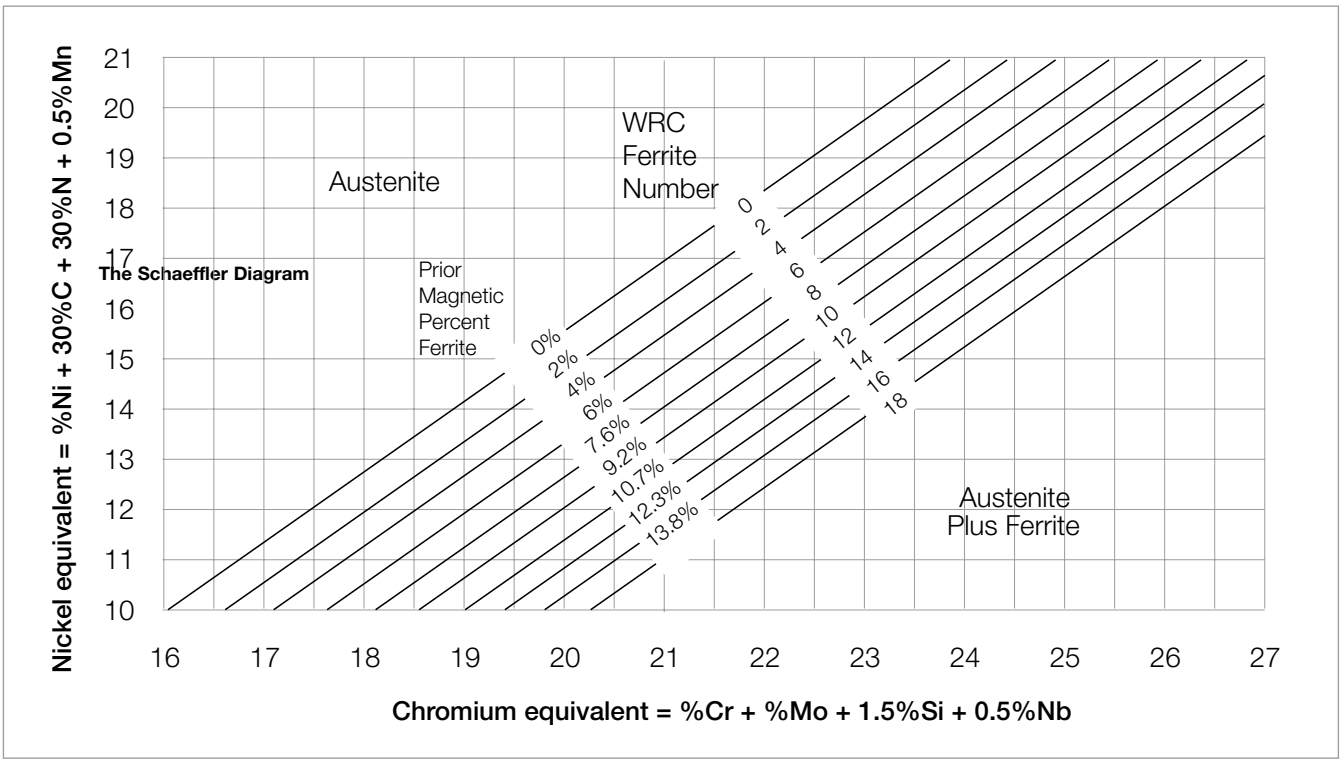
Parent metal HAZ considerations

When joining dissimilar steels it is important not only to select a consumable giving the desired weld metal structure when diluted by parent materials. The weldability of the steels must also be considered. A simple, although often overly conservative, guide is to use the same preheat, interpass temperature, post-weld heat treatment (PWHT) etc that would be used when welding the steels to themselves. However, a lower preheat can often be tolerated when an austenitic stainless or Ni-base filler is used.

A PWHT in the range 500-700ºC, that is commonly used for mild or low-alloy steels, can cause sensitisation (see Corrosion Types) of a stainless steel or weld metal, in particular for unstabilised grades with a high carbon content. PWHT might also cause embrittlement due to precipitation of intermetallic phases. The effect is more pronounced for weld metals with higher ferrite contents. A restriction to maximum 8-10 FN is therefore common, for example in cladding of low-alloy steels, when a PWHT is required.

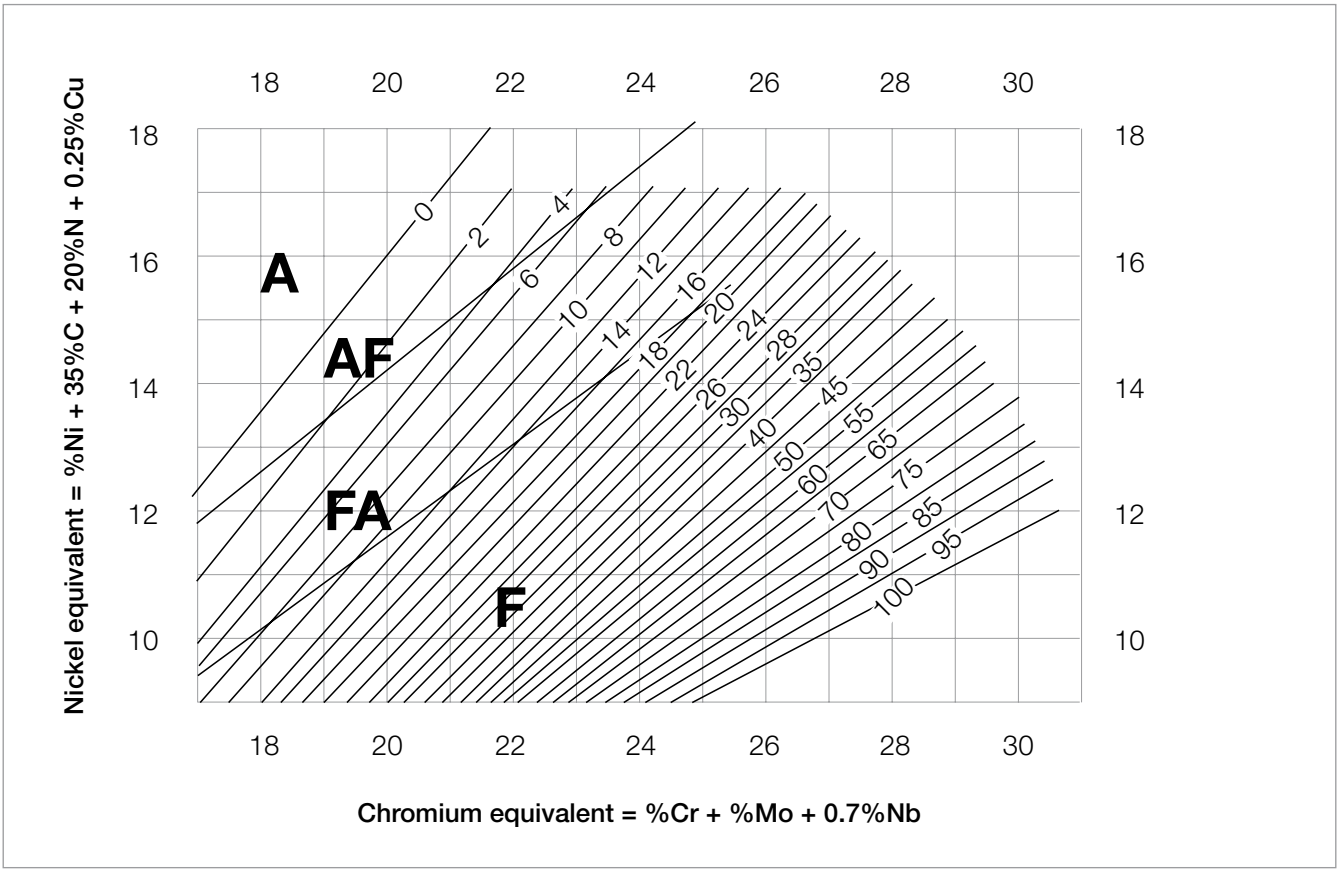


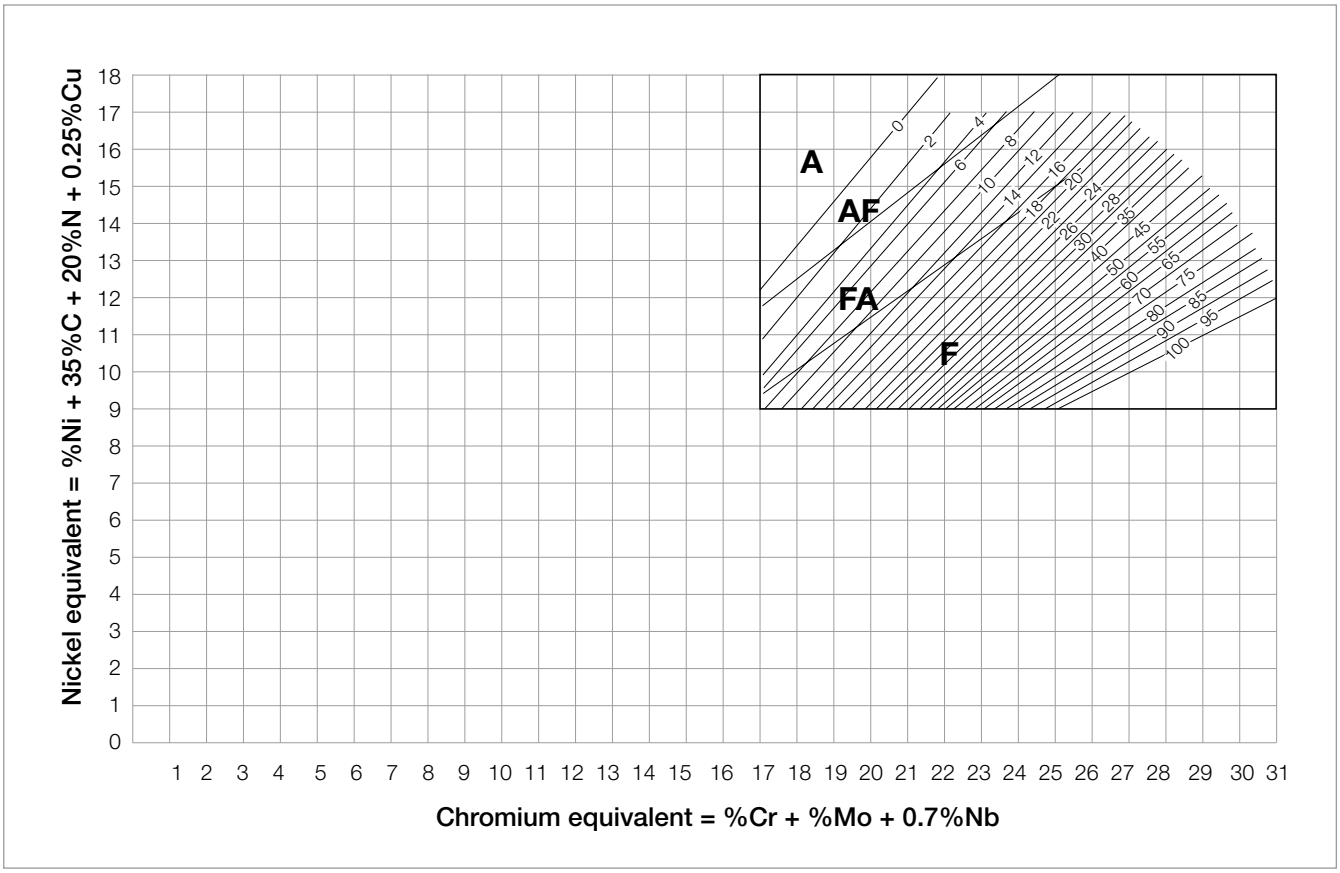
The Schaeffler Diagram



The Schaeffler Diagram

The DeLong Diagram





the WRC-1992 diagram (see Figures Z and W

Storage and handling

Storage

All covered electrodes are sensitive to moisture pick-up, but the rate will be very slow when stored under the correct climatic conditions:

- 5 – 15 °C: max. 60% RH
- 15 – 25 °C: max. 50% RH
- >25 °C: max. 40% RH

At low temperatures, maintain low relative humidity by keeping the storage temperature at least 10°C above the outside temperature. At high temperatures, maintain low relative humidity by air dehumidification. Ensure cold packs reach ambient temperature before opening. The plastic capsule provides some protection, although moisture permeates and is absorbed at a very slow rate. High moisture in the coating of stainless steel MMA electrodes can cause porosity. When uncertain about the moisture content, electrodes should be re-dried according to instructions. Use quivers for intermediate protection.

Handling VacPac™ electrodes

VacPac electrodes are to be stored below 50 °C and require no re-drying before use, provided that the package is undamaged. In order to protect the vacuum foil, do not use a knife or any other sharp object to open the outer package.
Before using VacPac™ electrodes. If the vacuum has been lost, then re-dry the electrodes before use.
Cut open the protective foil at the indicated end.
Do not take out more than one electrode at a time, while leaving the foil in place. Discard or re-dry electrodes exposed to the atmosphere in an opened Vac- Pac™ for more than 12 hours*.

Recommendations for solid and cored wires

Solid and cored wires should be stored in conditions which prevent the accelerated deterioration of products or packaging. All wires should avoid direct contact with water or moisture. Wires must be stored in dry conditions. The relative humidity and temperature should be monitored and the temperature should not fall below the dew point. To avoid condensation, the wires should be kept in the original packaging and, if necessary, left to warm up to at least the ambient temperature before opening the package. Other hydrogen-containing substances, such as oil, grease and corrosion, or hygroscopic substances must also be avoided. Storage must be adequate to prevent damage.

* Valid at standard AWS test conditions of 26.7 °C and 80% RH.

Recommendations for OK Flux

ESAB fluxes, agglomerated as well as fused, have a guaranteed low moisture content from production. Before transport, each pallet is shrink wrapped in plastic foil, to maintain the as-manufactured moisture content for as long as possible. Flux should never be exposed to direct wetness such as rain or snow.

Storage

Unopened flux bags must be kept under controlled storage condition as follows:

- Temperature: 20 +/- 10°C
- Relative humidity: not exceeding 60 %.
- Fluxes shall not be stored longer than 3 years.
- Remaining flux from unprotected hoppers must be placed in a drying cabinet or heated flux hopper at a temperature of 150 +/- 25°C.
- Remaining flux from open bags should be placed at a temperature of 150 +/- 25°C.

Recycling

- Moisture and oil must be removed from the pressure air used in the recycling system.
- New flux should be added in proportions of at least one part of new flux to three parts recycled flux.
- Foreign material such as millscale, dross etc. should be removed by, for instance, sieving.

Redrying

Redrying is needed when the flux has picked-up moisture during storage, handling or use or when required by material specification. Redrying shall be performed on shallow plates with a flux height not

- exceeding 50 mm, as follows:
- Agglomerated fluxes: 2-4h/300 +/- 25°C.
- Fused fluxes: 2-4h/200 +/- 50°C.

Redried flux, not immediately used, must be kept at 150 +/- 25°C before use.

Global manufacturing

OK Flux is an ESAB AB trademark and consequently the OK Flux range is fully globally managed, together with OK Autrod and OK Tubrod solid and cored SAW wires.

All ESAB plants manufacturing OK products do so based on centrally submitted specifications in terms of:

- Raw materials
- Testing methods
- Product release inspection
- Manufacturing process, process parameters and limits
- Product packaging and marking requirements
- Product 3rd party international approvals
- Product Lifecycle Management (PLM)
- Quality Management System
- ISO 14001
- OHSAS 18001

With all these measures in place, ESAB is confident that OK products have identical properties regardless of manufacturing location, worldwide.

Several OK products are made in more than one location to meet local geographical demands. Equally important, this is part of ESAB's supply contingency plan, a global effort to consistently meet the supply chain needs of our customers.

It is with this in mind that ESAB is able to supply a market from different factories, in order to provide the best possible delivery service.

26. Production facility certificates

World leader in welding and cutting technology and systems.

ESAB operates at the forefront of welding and cutting technology. Over one hundred years of continuous improvement in products and processes enables us to meet the challenges of technological advance in every sector in which ESAB operates.

Quality and environment standards

Quality, the environment and safety are three key areas of focus. ESAB is one of few international companies to have achieved the ISO 14001 and OHSAS 18001 standards in Environmental, Health & Safety Management Systems across all our global manufacturing facilities.

At ESAB, quality is an ongoing process that is at the heart of all our production processes and facilities worldwide.

Multinational manufacturing, local representation and an international network of independent distributors brings the benefits of ESAB quality and unrivalled expertise in materials and processes within reach of all our customers, wherever they are located.

ESAB Sales and Support Offices worldwide

* Includes manufacturing facilities of ESAB North America. A wholly owned subsidiary of Anderson Group Inc.

Global solutions for local customers - everywhere.

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