STAINLESS STEEL TECHNICAL HANDBOOK.

WELDING CONSUMABLES FOR JOINING AND CLADDING STAINLESS STEELS

GLOBAL MANUFACTURING.

All ESAB plants manufacturing filler metals 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 third party international approvals
- Product Lifecycle Management (PLM)
- Quality Management System
- ISO 14001
- OHSAS 18001

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

Several ESAB 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.

PRODUCTION FACILITY CERTIFICATES.

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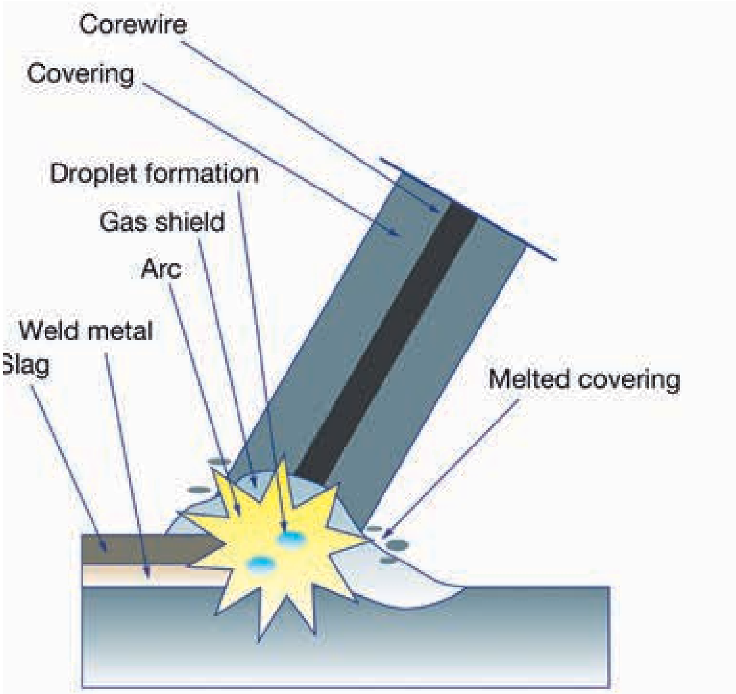
CONSUMABLES BY PARENT MATERIAL.

	EN Standard	Designation	No.	AISI (UNS)	Covered Electrodes for MMA Welding	Solid Wires for MIG/MAG Welding
Ferritic	10088-1	X2CrNi12	1.4003	S41050	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L OK Autrod 308LSi
	10088-1	X6Cr13	1.4000	403	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L OK Autrod 308LSi
	10088-1	X6Cr17	1.4016	430	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L, 308LSi, 430Ti, 430LNb, 430LNbTi
	10088-1	X2CrMoTi18-2	1.4521	S44400	OK 61.20, OK 61.30, OK 61.35	OK Autrod 308L OK Autrod 308LSi
	10088-1	-	1.4762	446	OK 67.15	OK Autrod 310
Austentic	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
	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
	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
	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
	10088-1	X8CrNiS18-9	1.4305	303	OK 68.81	OK Autrod 312
	10088-1	X6CrNiTi18-10	1.4541	321	OK 61.80, OK 61.81 OK 61.85, OK 61.86	OK Autrod 347Si
	10088-1	X6CrNiNb18-10	1.4550	347	OK 61.80, OK 61.81 OK 61.85, OK 61.86	OK Autrod 347Si
	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
	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
	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
	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
	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
	10088-1	X6CrNiMoTi17-12-2	1.4571	316Ti	OK 63.80, OK 63.85	OK Autrod 318Si
	10088-1	X6CrNiMoNb17-12-2	1.4580	316Nb	OK 63.80, OK 63.85	OK Autrod 318Si
	10088-1	X12CrMnNiN17-7-5	1.4372	201	OK 67.43, OK 67.45	OK Autrod 16.95
	10088-1	X2CrNiMo18-14-3	1.4435	S31603	OK 69.25	
	10088-1	X1CrNiMoN25-22-2	1.4466	310MoLN	OK 310Mo-L	OK Autrod 310
	10088-1	X1NiCrMoCu25-20-5	1.4539	N08904	OK 69.33	OK Autrod 385 OK Autrod NiCrMo-3
	10088-1	X2CrNiMo18-15-4	1.4438	S31703	OK 64.30	OK Autrod 385 OK Autrod NiCrMo-3
Heat Resistant Austenitic	10095	X15CrNi23-13	1.4833	309S	OK 67.60, OK 67.70, OK 67.75	OK Autrod 309LSi, OK Autrod 309MoL
	10095	X8CrNi25-21	1.4845	310S24	OK 67.13, OK 67.15	OK Autrod 310
	10095	X9CrNiSiNCe21-11-2	1.4835	S30815	OK 62.53	
Austenitic-Ferritic	10088-1	-	1.4162	S32101	OK 67.50, OK 67.53, OK 67.55	OK Autrod 2307
	10088-1	X2CrNiN23-4	1.4362	S32304	OK 67.50, OK 67.53, OK 67.55	OK Autrod 2307
	10088-1	X2CrNiMoN22-5-3	1.4462	S31803	OK 67.50, OK 67.53, OK 67.55	OK Autrod 2209
	10088-1	X2CrNiMoN25-7-4	1.4410	S32750	OK 68.53, OK 68.55	OK Autrod 2509
	10088-1	X2CrNiMoCuWN25-7-4	1.4501	S32760	OK 68.53, OK 68.55	OK Autrod 2509

	Wires for TIG Welding	Cored Wires for MIG/MAG	Wires for SAW 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, OK Tigrod 430LNbTi	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, Shield-Bright 347 X-tra	OK Autrod 347
	OK Tigrod 347Si	Shield-Bright 347, Shield-Bright 347 X-tra	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 NiCrMo-3		OK Autrod 385 OK Autrod NiCrMo-3
	OK Tigrod 385, OK Tigrod NiCrMo-3	Shield-Bright 317L, Shield-Bright 317L X-tra	OK Autrod 385 OK Autrod NiCrMo-3
	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 2307	Shield-Bright 2307	OK Autrod 2307
	OK Tigrod 2307	Shield-Bright 2307	OK Autrod 2307
	OK Tigrod 2209	Shield-Bright 2209	OK Autrod 2209
	OK Tigrod 2509	Shield-Bright 2594	OK Autrod 2509
	OK Tigrod 2509	Shield-Bright 2594	OK Autrod 2509

COVERED ELECTRODES—MMA WELDING.



Principle of manual metal arc welding.

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 fulfill 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 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 ionization 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 electrodes are supplied in VacPac vacuum packaging:

- ≤2.5 mm (≤3/32 in.): packed in quarter packs containing about 0.7 kg (1.5 lb.) each; each carton contains 6 packages
- 3.2 mm (1/8 in.): packed in half packs containing about 2 kg (4.4 lb.) each; each carton contains 3 packages
- ≥4.0 mm (≥5/32 in.): packed in half packs containing about 2 kg (4.4 lb.) each; each carton contains 6 packages

Plastic Capsules.

The main stainless types are also supplied in plastic capsules:

- ≤2.5 mm (≤3/32 in.): packed in quarter packs containing about 0.7 kg (1.5 lb.) each; each carton contains 9 packages
- ≥3.2 mm (≥1/8 in.): packed in half packs containing about 2 kg each; each carton contains 6 packages

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

MMA ELECTRODES – POSITIONAL WELDING 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 cooperation 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 and downhill welding of pipes with a wall thickness in the region of 2 mm (5/64 in.). The slag system allows a long pull-out length, reducing electrode change time loss.

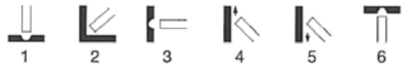
Low spatter, good slag release and good wetting minimise time loss in post-weld cleaning. Corrosion resistance meets the requirements of demanding environments found in, for example, the petrochemical and shipbuilding industries.

OK 61.20 is used for the vertical down welding of water supply piping in the pipeshop at a paper and pulp plant; AISI 304, 2.5 mm (3/32 in.) 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 manually rotated upwards.

- Productive Welding
- Reduced Post Weld Cleaning
- Good Corrosion Resistance in Demanding Environments

COVERED ELECTRODES—MMA WELDING.

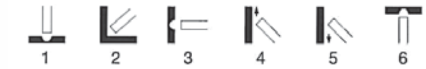
OK	Classifications	Approvals	Typical Weld Metal Composition (wt%)								Typical Ferrite	Typical Mechanical Properties All Weld Metal				
			C	Si	Mn	Cr	Ni	Mo	N	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** %	CVN °C/J	CVN °F/ft-lb
61.20	EN ISO 3581-A E 19 9 L R 1 1 AWS/SFA 5.4 E308L-16	CE TÜV	0.026	0.7	0.7	19.2	9.6		0.10		5	430 (62)	560 (81)	45*	+20/70 -50/40	68/52 -58/30
61.25	EN ISO 3581-A E 19 9 H B 2 2 AWS/SFA 5.4 E308H-15	NAKS/ HAKC Seproz	0.06	0.3	1.7	18.8	9.8		0.06		4	430 (62)	600 (87)	45*	+20/95 -18/83	68/70 0/61
61.30	EN ISO 3581-A E 19 9 L R 1 2 AWS/SFA 5.4 E308L-17	ABS CE CWB DB DNV-GL NAKS/ HAKC Seproz TÜV	0.03	0.9	0.7	19.3	10.0		0.09		5	430 (62)	580 (84)	45**	+20/70 -60/49	68/52 -76/36
61.35	EN ISO 3581-A 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		0.06		6	445 (65)	610 (88)	44*	+20/100 -120/70 -196/40	68/74 -184/52 -320/30
61.35 Cryo	EN ISO 3581-A 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	425 (62)	580 (84)	45*	+20/100 -120/70 -196/50	68/74 -184/52 -320/37
61.50	EN ISO 3581-A E 19 9 H R 1 2 AWS/SFA 5.4 E308H-17	NAKS/ HAKC	0.05	0.7	0.7	19.8	10.0		0.10		4	430 (62)	600 (87)	45*	+20/60	68/44
61.80	EN ISO 3581-A E 19 9 Nb R 1 2 AWS/SFA 5.4 E347-17	CE DNV-GL NAKS/ HAKC TÜV	0.03	0.7	0.6	19.5	10.0		0.09	Nb 0.29	7	480 (70)	620 (90)	40**	+20/60 -60/40	68/44 -76/30
61.81	EN ISO 3581-A E 19 9 Nb R 3 2 AWS/SFA 5.4 E347-16	CE DNV-GL NAKS/ HAKC	0.06	0.7	1.7	20.2	9.7		0.08	Nb 0.72	7	560 (81)	700 (102)	31*	+20/60 -10/71	68/44 14/52
61.85	EN ISO 3581-A E 19 9 Nb B 2 2 AWS/SFA 5.4 E347-15	NAKS/ HAKC Seproz TÜV	0.04	0.4	1.7	19.5	10.2		0.07	Nb 0.61	6	500 (73)	620 (90)	40	+20/100 -60/70 +20/80 -60/40	68/74 -76/52 68/59 -76/30
61.86	EN ISO 3581-A E 19 9 Nb R 1 2 AWS/SFA 5.4 E347-17	NAKS/ HAKC Seproz	<0.03	0.8	0.7	19.0	10.4		0.09	Nb 0.35	5	520 (75)	660 (96)	35*	+20/55	68/41



Coating	Recovery	Redrying		Diameter x Length		Current	Welding Positions	Description
		°C/2h	°F/2h	mm	in.	(A)		
Acid Rutile	105-108%	350	660	1.6x300 2.0x300 2.5x300	1/16x12 5/64x12 3/32x12	23-40 25-60 28-85 DC+/ AC/min. OCV: 50V	123456	Rutile coated electrode for welding 19Cr10Ni type steels. Suitable for welding stabilised steels of similar composition except when full creep resistance of base material is to be met. Especially designed for welding thin walled pipes. Diameters 1.6-2.5 mm (1/16-3/32 in.) can be used in all positions including vertical down.
Basic	104%	200	390	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	55-85 75-110 80-160 DC+	12346	Basic coated stainless electrode of 308H type especially designed for high temperature applications.
Acid Rutile	105%	350	660	1.6x300 2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	1/16x12 5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	35-45 35-65 50-90 70-130 90-180 140-250 DC+/ AC/min. OCV: 50V	12346 12346 12346 12346 12346 123	Extra low carbon stainless steel electrode for welding steels of 19Cr10Ni type. Suitable for welding stabilised stainless steels of similar composition, except when full creep resistance of base material is to be met.
Basic	100%	200	390	2.5x300 3.2x350 4.0x350 5.0x350	3/32x12 1/8x14 5/32x14 3/16x14	55-85 80-120 80-180 160-210 DC+	12346 12346 12346 123	Basic stainless electrode of 308L type designed for positional welding, e.g. piping. Suitable for applications where requirements concerning mechanical properties are demanding. Lateral expansion of min. 0.38 mm (~1/64 in.) is met down to -120°C (-184°F).
Basic	100%	200	390	2.5x300 3.2x350 4.0x350 5.0x350	3/32x12 1/8x14 5/32x14 3/16x14	55-85 80-120 80-180 160-210 DC+	12346 12346 12346 123	Basic stainless stick electrode of 308L type especially designed for cryogenic applications. Provides a controlled low ferrite content to ensure lateral expansion of min. 0.38 mm (~1/64 in.) at -196°C (-320°F).
Acid Rutile	101%	350	660	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	50-85 70-110 110-165 DC+/ AC/min. OCV: 55V	12346 12346 12	Stainless steel electrode for welding 19Cr9Ni austenitic stainless steels with carbon content >0.04%. Especially designed for high temperature applications.
Acid Rutile	103%	350	660	2.5x300 3.2x350 4.0x350 5.0x350	3/32x12 1/8x14 5/32x14 3/16x14	55-90 70-130 90-180 140-250 DC+/ AC/min. OCV: 50V	12346 12346 123 12	Niobium stabilised, stainless steel, LMA electrode with low carbon content for welding stainless types 321 and 347. To avoid excessive embrittlement of welds, should not be used in applications where working temperature exceeds 400°C (750°F).
Rutile	104- 106%	350	660	2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	40-60 50-80 75-115 80-160 140-210 DC+/ AC/min. OCV: 60V	12346 12346 12346 12346 1236	Niobium stabilised MMA electrode for welding niobium or titanium stabilised stainless steel of 19Cr10Ni type. Better hot cracking resistance than OK 61.80. To avoid excessive embrittlement of welds, it should not be used in applications where working temperature exceeds 400°C (750°F).
Basic	100- 107%	200	390	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	55-85 75-110 80-150 DC+	12346 12346 1234	Basic coated, niobium stabilised electrode of the E347 type, specially designed for welding niobium or titanium stabilised steels. Outstanding welding properties in vertical and overhead positions, making it particularly suited for pipe welding.
Acid Rutile	98-101%	350	660	3.2x350 4.0x350 5.0x350	1/8x14 5/32x14 3/16x14	70-120 120-170 150-240 DC+/ AC/min. OCV: 50V	12346 123456 123	Low carbon, niobium stabilised stainless steel electrode for welding niobium or titanium stabilised steels of 19Cr10Ni type. Specially designed for use in applications where heat treatment is required.

COVERED ELECTRODES—MMA WELDING.

ESAB	Classifications	Approvals	Typical Weld Metal Composition (wt%)								Typical Ferrite	Typical Mechanical Properties All Weld Metal				
OK			C	Si	Mn	Cr	Ni	Mo	N	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** %	CVN °C/J	CVN °F/ft-lb
62.53		Seproz	0.07	1.6	0.6	23.1	10.4	0.1	0.16		8	550 (80)	730 (106)	35*	+20/60	68/44
63.20	EN ISO 3581-A E 19 12 3 L R 1 1 AWS/SFA 5.4: E316L-16	CE CWB Seproz NAKS HAKC TÜV	0.02	0.7	0.7	18.4	12.1	2.8	0.11		4	480 (70)	590 (84)	41**	+20/56 -20/46	68/41 -4/34
63.30	EN ISO 3581-A E 19 12 3 L R 1 2 AWS/SFA 5.4: E316L-17	ABS, BV CE, CWB DB, DNV-GL, LR NAKS/ HAKC Seproz TÜV	0.02	0.8	0.6	18.1	11.0	2.6	0.10		6	460 (67)	570 (83)	40**	+20/60 -20/55 -60/43	68/44 -4/40 -76/32
63.34	EN ISO 3581-A E 19 12 3 L R 1 1 AWS/SFA 5.4: E316L-16	CWB Seproz TÜV	0.02	0.8	0.8	18.7	11.8	2.8	0.13		6	440 (64)	600 (87)	40**	+20/65 -120/38	68/48 -184/28
63.35	EN ISO 3581-A E 19 12 3 L B 2 2 AWS/SFA 5.4: E316L-15	ABS, CWB, NAKS/ HAKC Seproz TÜV	0.04	0.4	1.6	18.3	12.6	2.7	0.06		4	430 (62)	560 (84)	40**	+20/95 -60/75 -120/60 -196/35	68/70 -76/55 -184/44 -320/26
63.41	EN ISO 3581-A E 19 12 3 L R 5 3 AWS/SFA 5.4: E316L-26	CE DNV-GL LR TÜV	0.03	0.8	0.7	18.2	12.5	2.8	0.09		4	470 (68)	570 (83)	35*	+20/60 -60/52	68/44 -76/38
63.80	EN ISO 3581-A E 19 12 3 Nb R 3 2 AWS/SFA 5.4: E318-17	CE Seproz TÜV	0.02	0.8	0.6	18.2	11.5	2.9	0.08	Nb 0.31	7	507 (74)	614 (89)	38**	+20/55 -60/41	68/41 -76/30
63.85	EN ISO 3581-A E 19 12 3 Nb B 4 2 AWS/SFA 5.4: E318-15	Seproz TÜV	0.04	0.5	1.6	17.9	13.0	2.7	0.06	Nb 0.55	5	490 (71)	640 (93)	35*	+20/65 -120/45	68/48 -184/33
64.30	EN ISO 3581-A E 19 13 4 N L R 3 2 AWS/SFA 5.4: E317L-17	Seproz TÜV	0.02	0.7	0.7	18.4	13.1	3.6	0.08		8	480 (70)	600 (87)	35*	+20/45	68/33
67.13	EN ISO 3581-A E 25 20 R 1 2 AWS/SFA 5.4: E310-16		0.12	0.6	1.9	25.6	21.1				0	430 (62)	600 (87)	35*	+20/90	68/66



	Coating	Recovery	Redrying		Diameter x Length		Current	Welding Positions	Description
			°C/2h	°F/2h	mm	in.	(A)		
	Rutile	98-101%	350	660	2.5x300 3.2x350	3/32x12 1/8x14	50-90 70-110 DC+/ AC/min. OCV: 65V	12346 123	Rutile coated stainless electrode especially designed for heat resisting applications. Weld metal has scaling temperature of about 1150°C (2100°F). Recommended for welding Avesta 253 MA, steels such as AISI 309 and W.Nr 1.4828.
	Acid Rutile	100%	300	570	1.6x300 2.0x300 2.5x300 3.2x350	1/16x12 5/64x12 3/32x12 1/8x14	15-40 18-60 25-80 55-110 DC+/AC/min. OCV: 50V	123456 123456 123456 12346	Rutile coated electrode for welding 18Cr12Ni3Mo type steels. Suitable for welding stabilised steels of similar composition. Especially designed for welding thin walled pipes. Diameters 1.6-2.5 mm (1/16-3/32 in.) can be used in all positions including vertical down.
	Acid Rutile	102%	350	660	1.6x300 2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	1/16x12 5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	30 - 45 45 - 65 45 - 90 60 - 125 70 - 190 100 - 280 DC+/AC/min. OCV: 50V	12346 12346 12346 12346 12346 123	Extra low carbon stainless steel electrode for welding steels of 18Cr12Ni2.8Mo type. Suitable for welding stabilised stainless steels of similar composition, exept when full creep resistance of base metal is to be met.
	Acid Rutile	100%	350	660	2.5x300 3.2x350	3/32x12 1/8x14	70 - 90 80 - 130 DC+/AC/min. OCV: 60V	123456 123456	Stainless electrode of 19Cr12Ni2.8Mo type, designed for vertical down welding of steels of similar composition. Produces beads with very good finish and smooth transition to joint edges. Slag volume is small, easy to manipulate and remove.
	Basic	105%	200	390	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	55 - 85 80 - 120 80 – 180 DC+	12346 12346 12346	Low carbon stainless steel electrode of 18Cr12Ni3Mo type with basic coating for high mechanical requirement applications. Provides good impact toughness levels. Minimum lateral expansion of 0.38 mm (~1/64 in.) is met down to -120°C (-184°F). Same requirement obtained at -196°C (-320°F) when ferrite content is at low end of spec, e.g. FN 3-4.
	Acid Rutile	150%	350	660	2.5x300 3.2x350 4.0x450 5.0x450	3/32x12 1/8x14 5/32x14 3/16x14	60 - 90 80 - 130 110 - 180 170 - 240 DC+/AC/min. OCV: 55V	12346 123 123 12	High efficiency, low carbon stainless steel electrode for welding steels of type 18Cr12Ni2-3Mo.
	Acid Rutile	110%	350	660	2.0x300 2.5x300 3.2x350 4.0x350	5/64x12 3/32x12 1/8x14 5/32x14	45 - 65 60 - 90 80 - 120 120 - 170 DC+/AC/min. OCV: 55V	12346 12346 12346 123	Acid rutile covered MMA electrode for welding niobium or titanium stabilised steels of CrNiMo18-12-3 type.
	Basic	115%	200	390	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	50 - 80 65 - 120 75 - 160 DC+	12346 12346 12346	Basic MMA electrode for welding niobium stabilised stainless steels of 18Cr12Ni3Mo type.
	Acid Rutile	103-110%	350	660	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	50 - 80 60 - 120 80 - 170 DC+/AC/min. OCV: 55V	12346 12346 12346	Acid rutile electrode for welding 9Cr13Ni3.5Mo(317L) austenitic stainless steels. High Mo content provides better resistance to acid and pitting corrosion compared with 316L types. Easy to weld in all positions. Gives smooth runs on both AC and DC.
	Basic Rutile	95-100%	250	390	2.5x300 3.2x350 4.0x350 5.0x350	3/32x12 1/8x14 5/32x14 3/16x14	50 - 85 65 - 120 70 - 160 150 - 220 DC+/AC/min. OCV: 65V	12346 12346 12346 123	Austenitic stainless steel electrode for welding 25Cr20Ni steels. The weld metal resists scaling up to a temperature of 1100-1150°C (2010-2100°F) and does not contain any measureable ferrite. Can also be used for welding certain air-hardening steels such as armour plate and for welding stainless to unalloyed steel.

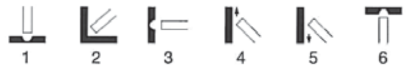
COVERED ELECTRODES—MMA WELDING.

ESAB	Classifications	Approvals	Typical Weld Metal Composition (wt%)								Typical Ferrite	Typical Mechanical Properties All Weld Metal				
OK			C	Si	Mn	Cr	Ni	Mo	N	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb
67.15	EN ISO 3581-A E 25 20 B 2 2 AWS/SFA 5.4: E310-15	CE DB Seproz TÜV	0.10	0.4	2.0	25.7	21.3				0	410 (59)	590 (84)	35**	+20/100	68/74
67.43	EN ISO 3581-A E 18 8 MN B 1 2 AWS/SFA 5.4: E307-16 EN 14700 E Fe10	CE DB Seproz TÜV	0.08	0.8	5.4	18.4	9.1				0	440	630	35	+20/80	68/59
67.45	EN ISO 3581-A E 18 8 Mn B 2 2 AWS/SFA 5.4: E307-15	ABS Seproz TÜV	0.09	0.3	6.3	18.8	9.1				<5	470	605	35	+20/85	68/63
67.50	EN ISO 3581-A E 22 9 3 N L R 3 2 AWS/SFA 5.4: E2209-17	ABS BV CE CWB DNV-GL Seproz TÜV	0.03	0.8	0.8	23.2	8.8	3.2	0.16		42	691	857	25	+20/50 -30/41	68/37 -22/30
67.53	EN ISO 3581-A E 22 9 3 N L R 1 2 AWS/SFA 5.4: E2209-16	DNV-GL TÜV	0.03	1.0	0.7	23.7	9.3	3.4	0.18		40	680	860	25	+20/48	68/35
67.55	EN ISO 3581-A E 22 9 3 N L B 2 2 AWS/SFA 5.4: E2209-15	DNV-GL Seproz TÜV	0.04	0.7	1.0	23.2	9.1	3.2	0.15		41	650	800	28	+20/100 -20/85 -60/65	68/74 -4/63 -76/48
67.60	EN ISO 3581-A E 23 12 L R 3 2 AWS/SFA 5.4: E309-17	CE CWB DNV-GL NAKS/HAKC Seproz TÜV	0.03	0.8	0.9	23.7	12.4		0.09		15	470	580	32	+20/50 -10/40	68/37 14/30
67.70	EN ISO 3581-A E 23 12 2 L R 3 2 AWS/SFA 5.4: E309LMo-17	ABS, BV CE, CWB DNV-GL NAKS/HAKC LR, RINA Seproz, TÜV	0.02	0.8	0.6	22.5	13.4	2.8	0.08		18	510	610	32	+20/50 -20/35	68/37 -4/26
67.71	EN ISO 3581-A E 23 12 2 L R 5 3 AWS/SFA 5.4: E309LMo-26	DNV-GL TÜV	0.04	0.9	0.9	22.9	13.3	2.6	0.08		15	500	620	35	+20/55 -60/30	68/41 -76/22
67.75	EN ISO 3581-A E 23 12 2 L B 4 2 AWS/SFA 5.4: E309L-15	ABS DNV-GL, LR NAKS/HAKC Seproz TÜV	0.04	0.3	2.0	23.5	12.9		0.06		11	470	600	35	+20/75 -80/55	68/55 -112/41

Coating	Recovery	Redrying		Diameter x Length		Current	Welding Positions	Description
		°C/2h	°F/2h	mm	in.	(A)		
Basic	100- 105%	200	390	2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	45 - 55 50 - 85 60 - 115 70 - 160 130 - 200 DC+	12346 12346 12346 123 123	Basic coated MMA electrode for welding 25Cr20Ni steels. Also suitable for welding armour steels, austenitic manganese steels and for joining dissimilar steels.
Rutile Basic	95-100%	350	660	2.5x300 3.2x350 4.0x350 5.0x450	3/32x12 1/8x14 5/32x14 3/16x14	60 - 80 90 - 115 100 - 150 130 - 210 DC+/AC/min. OCV: 65V	12346 12346 123 123	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 poor weldability.
Lime Basic	100%	200	390	2.5x300 3.2x350 4.0x350 5.0x450	3/32x12 1/8x14 5/32x14 3/16x14	50 - 80 70 - 100 80 - 140 150 - 200 DC+	12346 12346 12346 123	Austenitic stainless steel electrode producing a weld metal with less than 5% ferrite. Tough weld metal has excellent crack resistance, even when welding steels with poor weldability. Suitable for joining 12-14% Mn type steels to itself or other steels. Also suitable for depositing buffer layers before hardfacing.
Acid Rutile	103- 108%	350	660	2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	30 - 65 50 - 90 80 - 120 90 - 160 150 - 220 DC+/AC/min. OCV: 60V	12346 12346 12346 1234 12	Acid rutile coated MMA electrode for welding of austenitic-ferritic stainless steels of CrNiMoN-22-5-3 and CrNiN-23-4 types.
Rutile	97-105%	350	660	2.0x300 2.5x300	5/64x12 3/32x12	25 - 60 70 - 110 DC+/AC/min. OCV: 55V	123456 123456	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.
Basic	102- 106%	200	390	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	50 - 80 60 - 100 80 - 140 DC+	12346 12346 12346	Basic coated electrode specially designed for welding of duplex stainless steel, e.g. UNS S31803. Deposited weld metal gives very high ductility down to -50°C/-60°C (-58°F/-76°F). Suitable for welding duplex pipes in offshore applications.
Acid Rutile	115%	350	660	2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	45 - 65 45 - 90 65 - 120 85 - 180 110 - 250 DC+/AC/min. OCV: 55V	12346 12346 12346 12346 123	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.
Acid Rutile	106- 110%	350	660	2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	40 - 60 50 - 90 60 - 120 85 - 180 110 - 250 DC+/AC/min. OCV: 55V	12346 12346 12346 12346 123	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.
Acid Rutile	150%	350	660	3.2x350 4.0x450 5.0x450	1/8x14 5/32x14 3/16x14	60 - 130 110 - 170 170 - 230 DC+/AC/min. OCV: 70V	123 123 123	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.
Basic	120%	200	390	2.5x300 3.2x350 4.0x350 5.0x350	3/32x12 1/8x14 5/32x14 3/16x14	50 - 80 80 - 110 80 - 150 160 - 220 DC+	12346 12346 12346 123	Basic coated, stainless electrode for welding 24Cr13Ni type steels, 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.

COVERED ELECTRODES—MMA WELDING.

ESAB	Classifications	Approvals	Typical Weld Metal Composition (wt%)								Typical Ferrite	Typical Mechanical Properties All Weld Metal				
OK			C	Si	Mn	Cr	Ni	Mo	N	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb
68.15	EN ISO 3581-A E 13 B 4 2 AWS/SFA A5.4: E410-15 EN 14700 E Fe7	Seproz	0.04	0.4	0.3	12.9						370 *PWHT: 750°C/1h* (54)	520 (75)	25*	+20/55 0/35 -20/20 *PWHT: 750°C /6h*	68/41 -4/15
68.17	EN ISO 3581-A E 13 4 R 3 2 AWS/SFA A5.4: E410NiMo-16 EN 14700, E Fe7	Seproz	0.02	0.4	0.6	12.0	4.6	0.6				650 *PWHT: 600°C/2h +600°C/8h* (94)	870 (126)	17**	+20/45 -10/45 -40/40	68/33 14/33 -40/30
68.25	EN ISO 3581-A E 13 4 B 4 2 AWS/SFA A5.4: E410NiMo-15 EN 14700, E Fe7	Seproz	0.04	0.4	0.6	12.2	4.5	0.6				680 *PWHT: 600°C/8h* (99)	900 (130)	17**	+20/65 0/60 -20/55	68/48 32/44 -4/41
68.53	EN ISO 3581-A E 25 9 4 N L R 3 2 AWS/SFA A5.4: E2594-16	DNV-GL Seproz TÜV	0.03	0.6	0.7	25.2	10.3	4.0	0.25		39	700 (102)	850 (123)	30**	-40/40	-40/30
68.55	EN ISO 3581-A E 25 9 4 N L B 4 2 AWS/SFA A5.4: E2594-15	DNV-GL	0.03	0.6	0.9	25.2	10.4	4.3	0.23		45	700 (102)	900 (131)	28**	+20/90 -40/55 -60/45	68/66 -40/41 -76/33
68.81	EN ISO 3581-A E 29 9 R 3 2 AWS/SFA A5.4: E312-17 EN 14700 E Fe11	CE Seproz	0.13	0.7	0.9	28.9	10.2		0.09		40	610 (88)	790 (115)	22**	+20/30	68/22
68.82	EN ISO 3581-A E 29 9 R 3 2 AWS/SFA A5.4: (E312-17) EN 14700 E Fe11	CE Seproz	0.13	1.1	0.6	29.1	9.9		0.10		40	500 (73)	750 (109)	25**	+20/40	68/30
69.25	EN ISO 3581-A E 20 16 3 Mn N L B 4 2 AWS/SFA A5.4: E316LMn-15		0.04	0.5	6.5	19	16	3	0.15		<0.5	450 (65)	650 (94)	35**	+20/90 -196/50	68/66 -320/37
69.33	EN ISO 3581-A E 20 25 5 Cu N L R 3 2 AWS/SFA 5.4: E385-16	CE Seproz TÜV	0.03	0.5	1.0	20.5	25.5	4.8	0.10	Cu 1.7	0	410 (59)	590 (86)	35*	+20/80 -140/70	68/59 -220/52
310 Mo-L	EN ISO 3581-A E 25 22 N L R 1 2 AWS/SFA A5.4 E310Mo-16		0.038	0.4	4.4	24.2	21.7	2.4	0.14		0	442 (64)	623 (90)	34**	+20/54	68/40



	Coating	Recovery	Redrying		Diameter x Length		Current	Welding Positions	Description
			°C/2h	°F/2h	mm	in.	A		
	Lime Basic	108- 118%	200	390	2.5x350 3.2x450 4.0x450	3/32x12 1/8x14 5/32x14	65 - 115 90 - 160 120 - 220 DC+	12346 123 12	Stainless steel electrode which deposits a ferritic 13Cr weld metal. 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 welding parameters, structure and mechanical properties of untreated weld metal can vary within large limits.
	Rutile Basic	115- 118%	350	660	2.5x350 3.2x350 4.0x450	3/32x12 1/8x14 5/32x14	55 - 100 65 - 135 90 - 190 DC+/ AC/min. OCV: 55V	12346 12346 12346	Rutile basic electrode for welding martensitic 13Cr4Ni-Mo type steels.
	Basic	117- 121%	350	660	3.2x450 4.0x450 5.0x450	1/8x14 5/32x14 3/16x14	90 - 150 110 - 190 140 - 250 DC+	12346 12346 12	Basic coated electrode for welding corrrosion resistant martensitic and martensitic-ferritic rolled, forged and cast steels, e.g. castings of 13Cr4NiMo type.
	Basic Rutile	106%	250	480	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	55 - 85 70 - 110 80 - 150 DC+/ AC/min. OCV: 60V	12346 12346 12346	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.
	Basic	107- 109%	250	480	2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	50 - 80 60 - 100 100 - 140 DC+	12346 12346 12346	Basic coated electrode for welding austenitic-ferritic steels of the super duplex type, e.g. SAF 2507 and Zeron 100. Deposits a weld metal with high ductility.
	Acid Rutile	125%	350		2.0x300 2.5x300 3.2x350 4.0x350 5.0x350	5/64x12 3/32x12 1/8x14 5/32x14 3/16x14	40 - 60 50 - 85 60 - 125 80 - 175 150 - 240 DC+/ AC/min. OCV: 60V	12346 12346 12346 123 12	High recovery, high alloy stainless electrode of unusual versatility, giving a ferritic-austenitic duplex weld metal with approximate ferrite content of FN 50. Resistant to stress corrosion attack. Highly insensitive to dilution from parent metal. Good scaling resistance up to 1150°C (2100°F). Applications include joining HWT steels, dissimilar steels, surfacing rails, rolls, alforging dies, hot work tools, dies for plastics, etc.
	Acid Rutile	105%	300		2.0x300 2.5x300 3.2x350 4.0x350	5/64x12 3/32x12 1/8x14 5/32x14	40 - 60 50 - 85 55 - 120 75 - 170 DC+/ AC/min. OCV: 55V	12346 12346 12346 123	High alloy stainless electrode of unusual versatility, giving a ferritic-austenitic duplex weld metal with an approximate ferrite content of FN 50. Resistant to stress, corrosion attack. Highly insensitive to dilution from parent metal. Good scaling resistance up to 1150°C (2100°F). Applications include joining of HWT steels, dissimilar steels, welding steels of poor weldability, e.g. spring steels, surfacing rails, rolls forging die hot work tools, die for plastics, etc.
	Basic	115- 117%	200		3.2x350 4.0x350	1/8x14 5/32x14	70 - 100 100 - 140 DC+	12346 12346	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.
	Basic Rutile	110- 120%	250		2.5x300 3.2x350 4.0x350	3/32x12 1/8x14 5/32x14	60 - 85 85 - 130 160 - 240 DC+/ AC/min. OCV: 65V	12346 1234 123	Stainless steel electrode which deposits a fully austenitic weld metal with increased resistance to sulphuric acid. Good resistance to intergranular and pitting corrosion.
	Acid Rutile	100%	200		3.2x300 4.0x300	1/8x14 5/32x14	70 - 100 100-140 DC+	12346 1234	Rutile basic electrode for joining and cladding of 25%Cr 22%Ni 2%MoN steel. Excellent resistance to agressive corrosive media. Fully austenitic weld metal is insensitive to hot cracking. OK 310Mo-L is approved for the construction and repair of urea plants using stamicarbon process. Regularly used for routine repair works on AISI 316L in urea plants to gain superior resistance to corrosive attack.

ARCALOY ELECTRODES — US ONLY.

ESAB	Class	Typical Weld Metal Composition (wt%)							Typical Ferrite	Coating	Recovery	Redrying		Typical Mechanical Properties All Weld Metal				
Arcaloy		C	Si	Mn	Cr	Ni	Mo	N	FN					$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ ft-lb
308L-15	AWS/SFA 5.4 E308L-15	0.030	0.6	1.7	20.0	10.0	0.1		6	Basic	100%	200	390	430 (62)	520 (75)	45		
309L-15	AWS/SFA 5.4 E309L-15	0.040	0.5	1.8	24.0	13.5	0.3		9	Basic	120%	200	390	415 (60)	590 (86)	45		
316LF5-15	AWS/SFA 5.4 E316L-15	0.030	0.5	1.5	19.0	12.0	2.4		6	Basic	105%	200	390	450 (65)	560 (81)	40		
Cryoarc 316L	AWS/SFA 5.4 E316L-15	0.030	0.5	2.0	18.0	13.6	2.2	0.05	2 Max	Basic	105%	200	390	450 (65)	550 (80)	45	-196 /47	-320 /35
308L-16	AWS/SFA 5.4 E308L-16 CWB W48 E308L-16	0.030	0.5	1.7	20.0	10.0	0.1		6	Acid Rutile	105-108%	350	660	460 (65)	520 (75)	45		
309L-16	AWS/SFA 5.4 E309L-16 CWB W48 E309L-16	0.030	0.5	1.8	23.5	13.5	0.1		9	Acid Rutile	105-108%	350	660	450 (65)	590 (86)	37		
316LF5-16	AWS/SFA 5.4 E316L-16 CWB W48 E316L-16	0.030	0.4	1.5	19.0	12.0	2.5		6	Acid Rutile	100%	350	660	450 (65)	570 (83)	40		
308L-17 Plus	AWS/SFA 5.4 E308L-17	0.020	0.8	0.6	19.0	10.0	0.1		6	Acid Rutile	105%	350	660	400 (58)	550 (80)	47		
309L-17 Plus	AWS/SFA 5.4 E309L-17	0.025	0.7	0.6	23.5	13.5	0.1		15	Acid Rutile	115%	350	660	450 (65)	550 (80)	37		
316L-17 Plus	AWS/SFA 5.4 E316L-17	0.020	0.6	0.6	19.0	12.0	2.5		7	Acid Rutile	115%	350	660	440 (64)	570 (83)	45		
308/308H-16	AWS/SFA 5.4 E308-16 AWS/SFA 5.4 E308H-16	0.050	0.5	1.8	20.0	10.0	0.3		6	Acid Rutile	105-108%	350	660	410 (59)	610 (88)	44		
309/309H-16	AWS/SFA 5.4 E309-16 AWS/SFA 5.4 E309H-16	0.060	0.5	1.8	24.0	13.5	0.1		7	Acid Rutile	100%	350	660	380 (55)	620 (90)	40		
316/316H-16	AWS/SFA 5.4 E316-16 AWS/SFA 5.4 E316H-16	0.050	0.4	1.6	19.0	12.0	2.3		6	Acid Rutile	100%	350	660	450 (65)	570 (83)	40		

	Diameter x Length		Current	Welding Position	Description
	mm	in.	(A)		
	2.5x300 3.2x300 4.0x300	3/32x12 1/8x14 5/32x14	35-50 55-70 85-100	123456	Basic electrode for welding 304L type stainless steels. Can be used for other stainless steels including 301, 302 and 304 types. Used extensively for welding of chemical plant equipment and may be used successfully for welding of 321 and 347 types stainless steel provided the service temperature is less than about 371°C (700°F). The basic coating gives the highest resistance to cracking and excellent vertical welding characteristics.
	2.5x300 3.2x300 4.0x300	3/32x12 1/8x14 5/32x14	35-50 55-70 85-100	123456	Basic electrode for welding carbon and low alloy steels to stainless steels. This can be done provided the service temperature does not exceed about 371°C (700°F). Post weld heat treatment should only be taken with great care. Can be used as the first layer of stainless steel on carbon or low alloy steel.
	2.5x300 3.2x300 4.0x300	3/32x12 1/8x14 5/32x14	35-50 55-70 85-100	123456	Basic electrode designed to give a weld deposit with a minimum ferrite number of 5 FN. Carbon content is 0.04% maximum and can be used to weld 304L type stainless steel where the presence of molybdenum is not detrimental.
	2.5x300 3.2x300 4.0x300	3/32x12 1/8x14 5/32x14	35-50 55-70 85-100	12346	Basic electrode designed to be used in cryogenic applications where impact toughness is required. Cryoarc electrodes can also be used where low magnetic permeability is required.
	2.5x300 3.2x300 4.0x300 4.8x300	3/32x12 1/8x14 5/32x14 3/16x14	35-50 55-70 85-100 100-115	12346	Rutile coated electrode for welding 304 type steels. Also suitable for welding stabilised steels of similar composition, except when full creep resistance of base material is to be met.
	2.5x300 3.2x300 4.0x300 4.8x300	3/32x12 1/8x14 5/32x14 3/16x14	35-50 55-70 85-100 100-115	12346	Rutile coated electrode is used for welding carbon and low alloy steels to stainless steels. Post weld heat treatment should only be performed after due consideration.
	2.5x300 3.2x300 4.0x300 4.8x300	3/32x12 1/8x14 5/32x14 3/16x14	35-50 55-70 85-100 100-115	12346	Rutile coated electrode where the composition has been balanced to give a weld deposit with a minimum ferrite content of 5 FN. It can be used to weld 304L type stainless steel where the presence of molybdenum is not detrimental.
	2.5x300 3.2x300 4.0x300 4.8x300	3/32x12 1/8x14 5/32x14 3/16x14	35-50 55-70 85-100 100-115	12346	Low carbon stainless steel electrode for welding 304 type steels. Also suitable for welding stabilised stainless steels of similar composition, except when full creep resistance of base material is to be met.
	2.5x300 3.2x300 4.0x300 4.8x300	3/32x12 1/8x14 5/32x14 3/16x14	35-50 55-70 85-100 100-115	12346	Electrode with a heavy coating and produces a concave bead with minimal ripple. The slag is virtually self-cleaning. For welding carbon steel to stainless steel for service below about 315°C (600°F) and for the first layer when cladding.
	2.5x300 3.2x300 4.0x300 4.8x300	3/32x12 1/8x14 5/32x14 3/16x14	35-50 55-70 85-100 100-115	12346	Electrode with a heavy coating and produces a concave bead with minimal ripple. The slag is virtually self-cleaning. Molybdenum increases the resistance to pitting corrosion caused by corrosive media such as sulfuric and sulfurous acids, sulphites, chlorides and cellulose solutions. Ideal for welding 316 and 316L types of stainless steel when bead appearance is important.
	2.5x300 3.2x300 4.0x300	3/32x12 1/8x14 5/32x14	35-50 55-70 85-100	12346	Rutile coated electrode for welding 304H and 304 types where temperature in excess of 371°C (700°F) requires additional creep strength. The basic-rutile thin coating gives an excellent combination of welding performance in all positions and a high resistance to cracking. Operates on AC or DC current.
	2.5x300 3.2x300 4.0x300	3/32x12 1/8x14 5/32x14	35-50 55-70 85-100	12346	Rutile coated electrode is is used for welding base metal for all service temperatures designed for 309 type. Carbon content 0.04% minimum. It can be used for carbon and low alloy steels and stainless steel dissimilar joints.
	2.5x300 3.2x300	3/32x12 1/8x14	35-50 55-70	12346	Rutile coated electrode for use in applications where 316 type stainless steel needs improved high temperature. In some cases an E16-8-2 filler metal should be used. It can also be used to weld 316 type stainless steel for ambient temperature service.

SOLID WIRES—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 (~1/8 in.) 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 behavior 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. Gases normally used for stainless are:

- Argon + 1 - 2% oxygen)
- Argon + 2 - 3% carbon dioxide
- Argon + helium + carbon dioxide + hydrogen

Current and Voltage Recommendations

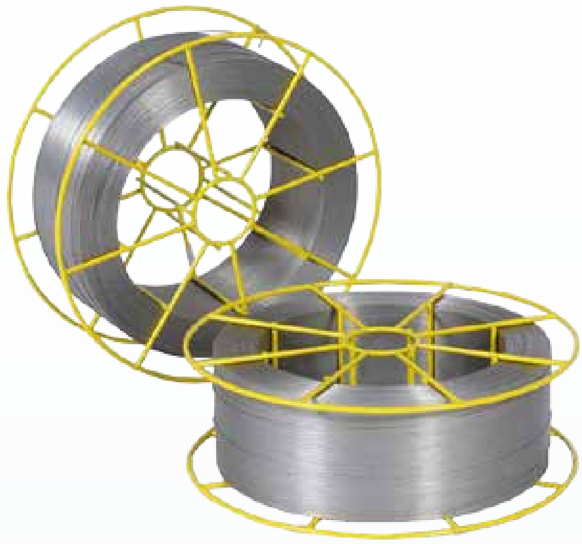
Diameter mm (in.)	Arc Voltage (V)	Current (A)
0.8 (0.030)	16-22	50-140
0.9 (0.035)	16-24	60-160
1.0 (0.039)	16-24	80-190
1.1 (0.045)	20-28	150-240
1.2 (0.047)	20-28	180-280
1.6 (1/16)	24-28	250-350

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 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 max. 0.03% carbon) an increase in 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 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.



ESAB matte stainless steel MIG wire.

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 (12 in.). Net weight of the spool is 15 kg (33 lb.). The wire is precision wound and the spool is used without adapter. Some grades in smaller diameters are also available in 5 kg (11 lb.) spools, No. 46 (EN 759: S200), a plastic spool with an outer diameter of 200 mm (7.875 in.).

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. Marathon Pac is also 100% recyclable. The table below reviews the complete Marathon Pac family.

Marathon Pac Family		
Description	Weight kg (lb.)	Width x Height mm (in.)
Mini Marathon Pac	100 (220)	513x500 (20x20)
Standard Marathon Pac	250 (550)	513x830 (20x33)
Jumbo Marathon Pac	500 (1100)	595x935 (23x37)

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 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, 1.1, 1.2 and 1.6 mm (0.030, 0.035, 0.039, 0.045, 0.047 and 1/16 in).

Matte Wire.

The most common grades are produced with a matte 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 matte surface is finished with a special feed-aid that does not accumulate within the feeding system or welding gun.

SOLID WIRES—MIG/MAG WELDING.

ESAB	Classifications	Approvals	Typical Wire Composition (wt%)								Typical Ferrite	Typical Mechanical Properties All Weld Metal				
OK Autrod			C	Si	Mn	Cr	Ni	Mo	N	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb
16.95	EN ISO 14343-A W 18 8 Mn AWS/SFA 5.9: ER307Si (mod)		0.08	0.9	7	18.7	8.1	0.2	<0.08	Tot <0.5		450 (65)	640 (93)	41	+20/130	68/88
308L	EN ISO 14343-A G 19 9 L AWS/SFA 5.9: ER308L		0.02	0.4	1.9	19.8	9.8	0.20	<0.08	Cu 0.15 Tot <0.5	9	450 (65)	620 (90)	36	-20/110 -60/90 -196/60	68/81 -76/66 -320/44
308LSi	EN ISO 14343-A G 19 9 LSi AWS/SFA 5.9: ER308LSi	CE DB DNV-GL TÜV CWB NAKS/ HAKC	0.01	0.9	1.8	19.9	10.5	0.15	<0.08	Cu 0.10 Tot <0.5	8	400 (58)	570 (83)	36	+20/110 -60/70 -196/46	68/81 -76/52 -320/34
308H	EN ISO 14343-A G 19 9 H AWS/SFA 5.9: ER308H		0.05	0.5	1.9	19.8	9.2	0.15		Tot <0.5	8	Min. 350	Min. 550 (80)	Min. 30		
309L	EN ISO 14343-A G 23 12 L AWS/SFA 5.9: ER309L	CE	0.02	0.4	1.8	23.2	13.4	0.10	<0.08	Tot <0.5	10	440 (64)	600 (87)	41	+20/160 -60/130 -110/90	68/118 -76/96 -166/66
309LSi	EN ISO 14343-A G 23 12 LSi AWS/SFA 5.9: ER309LSi	CE DB TÜV CWB	0.02	0.9	1.7	23.4	13.5	0.15		Tot <0.5	9	440 (64)	600 (87)	41	+20/160 -60/130 -110/90	68/118 -76/96 -166/66
309Si	EN ISO 14343-A G 22 12 H AWS/SFA 5.9: ER309Si		0.08	0.9	1.8	23.3	12.7	0.20			5	440 (64)	620 (90)	36	+20/100 -60/80 -110/60	68/74 -76/59 -166/44
309MoL	EN ISO 14343-A G 23 12 L AWS/SFA 5.9: ER309MoL	CE TÜV	0.01	0.4	1.5	21.4	14.6	2.5		Tot <0.5	8	400 (58)	600 (87)	31	+20/110 -60/65	68/81 -76/51
310	EN ISO 14343-A G 25 20 AWS/SFA 5.9: ER310		0.10	0.4	1.6		25.8	20.7	0.1	Tot <0.5		390 (57)	590 (86)	43	+20/175 -196/60	68/129 -320/44
312	EN ISO 14343-A G 29 9 AWS/SFA 5.9: ER312		0.10	0.4	1.6	30.7	8.8	0.20		Tot <0.5		610 (88)	770 (112)	20	+20/50	68/37
316L	EN ISO 14343-A G 19 12 3 L AWS/SFA 5.9: ER316L		0.01	0.4	1.7	18.2	12.0	2.6	<0.08	Tot <0.5	7	440 (64)	620 (90)	37	+20/120 -60/95 -196/55	68/89 -76/70 -320/41
316LSi	EN ISO 14343-A G 19 12 3 LSi AWS/SFA 5.9: ER316LSi	CE DB DNV-GL TÜV CWB NAKS/ HAKC	0.01	0.9	1.8	18.4	12.2	2.6	<0.08	Tot <0.5	7	400 (58)	560 (81)	37	+20/120 -60/95 -110/70 -196/55	68/89 -76/70 -166/52 -320/41

	Description
	A continuous, solid, corrosion resistant chromium-nickel-manganese wire for welding austenitic stainless alloys of 18% Cr, 8% Ni, 7% Mn types. Overall corrosion resistance similar to that of corresponding parent metal. Higher silicon content improves welding properties, such as wetting. A modified variant of ER307, basically with a higher Mn content to make weld less sensitive to hot cracking. When used for joining dissimilar materials, corrosion resistance is of secondary importance. Used in a wide range of applications across industry, such as joining of austenitic, manganese, work hardenable steels as well as armourplate and heat resistant steels.
	A continuous, solid, corrosion resistant chromium-nickel wire. 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. Widely used in 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 same type if service temperature will not exceed 350°C (660°F).
	A continuous, solid, corrosion resistant chromium-nickel wire for welding austenitic chromium-nickel alloys of 18% Cr, 8% Ni type. Good general corrosion resistance. The alloy has a low carbon content, making it particularly recommended when there is a risk of intergranular corrosion. Higher silicon content improves welding properties such as wetting. Widely used in chemical and food processing industries, as well as for pipes, tubes and boilers.
	A continuous, solid, corrosion resistant chromium-nickel wire for welding austenitic chromium-nickel alloys of 18% Cr, 8% Ni type. Good general corrosion resistance. The alloy has a high carbon content, suitable for applications used at higher temperatures. Used in chemical and petrochemical plants for welding of pipes, cyclones and boilers.
	A continuous, solid, corrosion resistant chromium-nickel wire for welding similar steels, wrought and cast steels of 23% Cr, 12% Ni types. Used for welding of buffer layers on CMn steels and welding of dissimilar joints. When using the wire for buffer layers and dissimilar joints, it is necessary to control dilution of weld. Good general corrosion resistance. When used for joining dissimilar materials, corrosion resistance is of secondary importance.
	A continuous, solid, corrosion resistant chromium-nickel wire for welding steels with a similar composition, wrought and cast steels of 23% Cr, 12% Ni types. Used for welding buffer layers on CMn steels and welding dissimilar joints. When using wire for buffer layers and dissimilar joints, it is necessary to control dilution of weld. Good general corrosion resistance. Higher silicon content improves welding properties such as wetting.
	A continous, solid, corrosion resistant chromium-nickel wire for joining stainless steels to non or low alloyed steels, as well as welding of austenitic stainless alloys of 24% Cr, 13% Ni, high C type. Good general corrosion resistance. Higher silicon content improves welding properties, such as wetting. When used for joining dissimilar materials, corrosion resistance is of secondary importance.
	A continuous, solid, corrosion resistant wire of 309LMo type. Used for 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.
	A continuous, solid, corrosion resistant chromium-nickel wire for welding heat resistant austenitic steels of 25% Cr, 20% Ni type. Good overall oxidation resistance, especially at high temperatures, due to its high Cr content. The alloy is fully austenitic and sensitive to hot cracking. Common applications include industrial furnaces and boiler parts, as well as heat exchangers.
	A continuous, solid, corrosion resistant chromium-nickel wire for welding stainless steels of 29% Cr, 9% Ni type. Good oxidation resistance at high temperatures due to its high content of Cr. Widely used for joining dissimilar steels, especially if one of the components is fully austenitic, and steels that are difficult to weld, e.g. machine components, tools and austenitic-manganese steels.
	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. 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. Widely used in chemical and food processing industries as well as in shipbuilding and various types of architectural structures.
	A continuous, solid, corrosion resistant chromium-nickel-molybdenum wire for welding austenitic stainless alloys of 18% Cr, 8% Ni and 18% Cr, 10% Ni, 3% Mo type. Good overall corrosion resistance. Alloy has very good resistance to corrosion in acid and chlorinated environments. Low carbon content makes it particularly recommended when there is a risk of intergranular corrosion. Higher silicon content improves welding properties such as wetting. Widely used in chemical and food processing industries.

SOLID WIRES—MIG/MAG WELDING.

ESAB	Classifications	Approvals	Typical Wire Composition (wt%)								Typical Ferrite	Typical Mechanical Properties All Weld Metal				
OK Autrod			C	Si	Mn	Cr	Ni	Mo	N	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb
316LMn	EN ISO 14343-A S 20 16 3 Mn N L AWS/SFA A5.9: ER316LMn		0.02	0.3	7	20	16	3	0.15			400 (58)	600 (87)	40	-60/90 -110/70 -196/40	-75/66 -165/52 -320/30
317L	EN ISO 14343-A G 18 15 3 L AWS/SFA 5.9: ER317L		0.01	0.4	1.4	18.9	13.6	3.6	<0.08		7	390 (57)	600 (87)	45	+20/135 -196/55	68/100 -320/43
318Si	EN ISO 14343-A G 19 12 3 Nb Si AWS/SFA 5.9: ER318Si	DB TÜV CE NAKS/ HAKC	0.05	0.8	1.7	18.8	11.9	2.6	<0.08	Nb 0.5 Cu 0.1 Tot <0.5	6	460 (67)	615 (89)	35	+20/100 -60/70	68/74 -76/52
347Si	EN ISO 14343-A G 19 9 Nb Si AWS/SFA 5.9: ER347Si	DB TÜV CE NAKS/ HAKC	0.04	0.7	1.7	19.0	9.8	0.1	<0.08	Nb 0.6 Cu 0.1 Tot <0.5	7	440 (64)	640 (93)	37	+20/110 -60/80	68/81 -76/59
385	EN ISO 14343-A G 20 25 5 Cu L AWS/SFA 5.9: ER385		0.01	0.4	1.7	20.0	25.0	4.4	<0.08	Cu 1.5 Tot <0.5		340 (49)	540 (78)	37	+20/120	68/89
2209	EN ISO 14343-A G 22 9 3 N L AWS/SFA 5.9: ER2209	CE DB DNV-GL TÜV NAKS/ HAKC	0.01	0.5	1.5	22.7	8.5	3.2	0.17		45	590 (86)	785 (114)	31	+20/100 -20/85 -60/60	68/74 -4/63 -76/44
2307	EN ISO 14343-A G 23 7 NL	CE	0.01	0.5	1.4	23.2	7.1	3.2	0.15		40	560 (81)	730 (106)	32	+20/160 -60/60	68/118 -76/44
2509	EN ISO 14343-A G 25 9 4 N L AWS/SFA 5.9: ER2594	CE	0.01	0.4	0.4	25.2	9.4	3.9	0.24		40	660 (96)	830 (120)	30	+20/159 -40/129	68/117 -40/95
410NiMo	EN ISO 14343-A G 13 4 AWS/SFA 5.9: ER410NiMo (mod)		0.02	0.4	0.5	12.4	4.2	0.6		Tot <0.5		860 (124)	1050 (152)	13	0/35 -20/30	32/25 -4/22
409Nb	AWS/SFA 5.9: ER409Nb		0.03	0.7	0.5	11.3	0.3	0.1		Nb >10xC		250 (36)	450 (65)	15		
430LNb	EN ISO 14343-A G Z 18 L Nb		0.01	0.5	0.5	18.5	0.2	0.06		Nb>12xC Tot <0.5		275 (40)	420 (61)	26		
430LNbTi	EN ISO 14343-A G Z 18 L Nb Ti		0.01	0.5	0.5	18.5	0.2	0.06		Ti 0.20 Nb Min 0.05+ 7x(C+N)		270 (39)	415 (60)	25		
430Ti	EN ISO 14343-A G Z 17 Ti	CE	0.07	0.9	0.5	17.6	0.3	0.05		Ti 0.4 Tot <0.5		380 (55)	580 (84)	28		
439Ti	EN ISO 14343- A: G Z 18 L TiAWS/SFA A5.9: ER439Ti (mod)		0.01	0.5	0.5	18.5	0.2	0.06		Ti 0.20		270 (39)	420 (60)	26		

	Description
	A continuous solid corrosion resisting non-magnetic chromium-nickel-molybdenium wire for welding of stabilised and non-stabilised austenitic alloys of the same type as well as non magnetic steels. The alloy is corrosion resistant in seawater environment and has very good corrosion resistance to acids such as nitric acid. Excellent impact properties at low temperatures.
	A continous, solid, corrosion resistant chromium-nickel-molybdenum wire for welding of austenitic stainless alloys of 19% Cr, 13% Ni, 3% Mo type. Good resistance to general corrosion and pitting, due to its high content of molybdenum. Low carbon content makes it particularly recommended when there is a risk of intergranular corrosion. Used in severe corrosion conditions, such as in petrochemical, pulp and paper industries.
	A continuous, solid, corrosion resistant stabilised chromium–nickel-molybdenum wire for welding of Cr-Ni-Mo and Cr-Ni stabilised or non-stabilised steels. Good overall corrosion resistance. Stabilised with Ni to improve resistance against intergranular corrosion of weld metal. Higher silicon content improves welding properties, such as wetting. Due to stabilisation of niobium, this alloy is recommended for service temperatures up to 400°C (750°F).
	A continuous, solid, corrosion resistant chromium-nickel wire for welding austenitic chromium-nickel alloys of 18% Cr-8% Ni type. Good overall corrosion resistance. Stabilised with niobium to improve resistance to intergranular corrosion of weld metal. Higher silicon content improves welding properties such as wetting. Due to niobium content, this alloy is recommended for use at higher temperatures.
	A continuous, solid, corrosion resistant chromium-nickel-molybdenum-copper wire for welding austenitic stainless alloys of 20% Cr, 25% Ni, 5% Mo, 1.5% Cu, low C types. Good resistance to stress corrosion and intergranular corrosion and shows very good resistance to attack in non-oxidising acids. Resistance to crevice corrosion is better than that of ordinary 18% Cr, 8% Ni, Mo steels. Widely used in many applications related to process industry.
	A continuous, solid, corrosion resistant duplex wire for welding austenitic-ferritic stainless alloys of 22% Cr, 5% Ni, 3% Mo type. 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. Used in a variety of applications across all industrial segments.
	A continous, solid, corrosion resistant duplex wire for welding austenitic-ferritic stainless alloys of 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 interpass temperature should not exceed 150°C (300°F).
	A continuous, solid, corrosion resistant super duplex wire for welding austenitic-ferritic, stainless alloys of 25% Cr, 7% Ni, 4% Mo, low C type. High intergranular-corrosion, pitting and stress-corrosion resistance. Widely used in applications in which corrosion resistance is of utmost importance, such as pulp and paper, offshore and gas industries.
	A continuous, solid welding wire of 12% Cr, 4.5% Ni, 0.5% Mo type. Used for welding similar martensitic and martensitic-ferritic steels in different applications, such as hydro turbines.
	A ferritic, stabilised, stainless, solid welding wire of the 12% Cr and 0.4% Nb type. Used for welding of equivalent steels in applications, such as catalytic converters and mufflers.
	A continuous ferritic, stainless, solid wire with a low carbon content, 18% Cr and stabilised with Nb, for welding similar and matching steels. Developed for automotive industry and used in 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) 1.5 mm (0.059in.).
	A ferritic, stainless, solid wire with low carbon content and excellent welding properties. Contains 18% Cr and is stabilised with Nb and Ti, for welding equivalent and matching steels. Developed for automotive industry and used for production of exhaust systems. The wire should be used when there is a need for very high resistance to corrosion and thermal fatigue.
	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. Widely used in automotive industry for welding of manifolds, catalytic converters and exhaust pipes. Mechanical properties after heat treatment 780˚C/0.5h (1440°F/0.5h).
	A ferritic, stainless, solid wire containing 18% Cr and is stabilised with Ti, for welding equivalent and matching steels. Developed for automotive exhaust industry. The wire should be used when there is a need for very high resistance to corrosion and thermal fatigue.

SOLID WIRES—TIG WELDING.

Welding Data.

Stainless steel is TIG welded with direct current, straight polarity, e.g. 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 30-40A per mm of material thickness.

TIG welding is particularly suitable for lighter materials; metals as thin as 0.3 mm (0.012 in.) can be welded successfully. For heavier materials, more than 5-6 mm (3/16-1/4 in.) 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 mechanized 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.

ESAB	Classifications	Approvals	Typical Wire Composition (wt%)							Typical Ferrite	Typical Mechanical Properties All Weld Metal				
														CVN	
OK Tigrod			C	Si	Mn	Cr	Ni	Mo	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	°C/J	°F/ft-lb
16.95	EN ISO 14343-A W 18 8 Mn AWS/SFA 5.9: ER307Si (mod)	DB TÜV CE	0.08	0.9	7.0	18.7	8.1	0.2	Tot <0.5		450 (65)	640 (93)	41	+20/130 -60/56	68/96 -76/41
308L	EN ISO 14343-A: W 19 9 L AWS/SFA 5.9: ER308L	DNV-GL TÜV CWB NAKS/ HAKC	0.02	0.4	1.9	19.8	9.8	0.20	Tot <0.5	9	480 (70)	610 (88)	36	+20/170 -80/135 -196/90	68/125 -76/100 -320/66
308LSi	EN ISO 14343-A: W 19 9 LSi AWS/SFA 5.9: ER308LSi	CE DNV-GL TÜV CWB NAKS/ HAKC	0.01	0.9	1.8	19.9	10.5	0.15	Tot <0.5	9	480 (70)	625 (91)	37	+20/170 -60/150 -110/140 -196/75	68/125 -76/110 -166/103 -320/55
308H	EN ISO 14343-A: W 19 9 H AWS/SFA 5.9: ER308H		0.05	0.5	1.9	19.8	9.2	0.15	Tot<0.5	8	350 (51)	550 (80)	30		
309L	EN ISO 14343-A: W 23 12 L AWS/SFA 5.9: ER309L	CE TÜV CWB NAKS/ HAKC	0.02	0.4	1.8	23.2	13.4	0.10	Tot <0.5	9	430 (62)	590 (86)	40	+20/160 -60/130 -110/90	68/118 -76/96 -166/66
309 LSi	EN ISO 14343-A: W 23 12 LSi AWS/SFA 5.9: ER309LSi	CE DB NAKS/ HAKC	0.02	0.9	1.7	23.4	13.5	0.15	Tot <0.5	9	475 (70)	635 (92)	32	+20/150 0/150 -60/150 -110/130	68/110 0/110 -76/110 -320/96
309 MoL	EN ISO 14343-A: W 23 12 2 L AWS/SFA 5.9: ER309MoL	DNV	0.01	0.4	1.5	21.4	14.6	2.5	Tot <0.5	8	500 (73)	610 (88)	30	+20/140 -60/65	68/103 -76/50
310	EN ISO 14343-A: W 25 20 AWS/SFA 5.9: ER310		0.10	0.4	1.7	25.8	20.7	0.10	Tot <0.5		390 (57)	590 (86)	43	+20/175 -196/60	68/129 -320/44

Recommended Current Ranges			
Electrode Diameter		Pure Tungsten	Alloyed Tungsten Electrode
mm	in.		
1.6	1/16	40-130	60-150
2.4	3/32	130-230	170-250
3.2	1/8	160-310	225-330
4.0	5/32	275-450	350-480

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 (11 lb.). This solution is a rigid fiber 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.

	Description
	Bare, corrosion resistant, chromium-nickel-manganese welding rod for welding austenitic stainless alloys of 18% Cr, 8% Ni, 7% Mn type. Overall corrosion resistance similar to corresponding parent metal. Higher silicon content improves welding properties, such as wetting. When used for joining dissimilar materials, corrosion resistance is of secondary importance. 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.
	Bare, corrosion resistant, chromium-nickel TIG rod. Good general corrosion resistance. Low carbon content makes it particularly recommended when there is a risk of intergranular corrosion. Widely used in chemical and food processing industries, as well as pipes, tubes and boilers. Suitable for joining of stainless steels of 18% Cr, 8% Ni type with low carbon content and Nb stabilised steels of the same type if service temperature does not exceed 350°C (660°F). Can be used for welding Cr steels, except in sulphur rich environments.
	Bare, corrosion resistant, chromium-nickel rods for welding austenitic chromium-nickel alloys of 18% Cr, 8% Ni type. Good overall corrosion resistance. Low carbon content makes it particularly recommended when there is a risk of intergranular corrosion. Higher silicon content improves welding properties such as wetting. Widely used in chemical and food processing industries, as well as pipes, tubes and boilers.
	Bare, corrosion resistant, chromium-nickel rods for welding austenic chromium-nickel alloys of 18% Cr, 8% Ni type. Good general corrosion resistance. High carbon content makes it suitable for applications at higher temperatures. Used in chemical and petrochemical industries for welding of tubes, cyclones and boilers.
	Bare, corrosion resistant, chromium-nickel welding rod for welding 24% Cr, 13% Ni alloyed types of steel. 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 dilution of weld. Good overall corrosion resistance. When used for joining dissimilar materials, corrosion resistance is of secondary importance.
	Bare, corrosion resistant, chromium-nickel welding rod for welding steels with similar composition, wrought and cast steels of 23% Cr, 12% Ni type. 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 dilution of weld. Good overall corrosion resistance. Higher silicon content improves welding properties such as wetting.
	Bare, corrosion resistant rod of 309LMo type. Used for 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.
	Bare, corrosion resistant, chromium-nickel welding rod for welding heat resistant austenitic steels of 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.

SOLID WIRES—TIG WELDING.

ESAB	Classifications	Approvals	Typical Wire Composition (wt%)							Typical Ferrite	Typical Mechanical Properties All Weld Metal				
OK Tigrod			C	Si	Mn	Cr	Ni	Mo	Others	FN	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb
312	EN ISO 14343-A: W 29 9 AWS/SFA 5.9: ER312		0.10	0.4	1.6	30.7	8.8	0.20	Tot <0.5		610 (88)	770 (112)	20	+20/50	68/37
316L	EN ISO 14343-A: W 19 12 3 L AWS/SFA 5.9: ER316L	CE ABS DNV-GL TÜV CWB NAKS/ HAKC	0.01	0.4	1.7	18.2	12.0	2.6	Tot <0.5	7	470 (68)	600 (87)	32	+20/175 -60/130 -110/120 -196/75	68/129 -76/96 -166/89 -320/55
316LSi	EN ISO 14343-A: W 19 12 3 LSi AWS/SFA 5.9: ER316LSi	CE DB BV DNV-GL TÜV NAKS/ HAKC	0.01	0.9	1.8	18.4	12.2	2.6	Tot <0.5	7	500 (73)	630 (91)	33	+20/175 -110/110 -196/90	68/129 -166/81 -320/66
317L	EN ISO 14343-A: W 18 15 3 L AWS/SFA 5.9: ER317L		0.01	0.4	1.4	18.9	13.6	3.6		7	390 (57)	600 (87)	45	+20/135 -196/55	68/100 -320/41
318Si	EN ISO 14343-A: W 19 12 3 NbSi	DB TÜV CE	0.05	0.8	1.7	18.8	11.9	2.6	Nb 0.5 Cu 0.1 Tot <0.5	6	460 (67)	615 (89)	35	+20/40 -60/70	68/30 -76/52
347	EN ISO 14343-A: W 19 9 Nb AWS/SFA 5.9: ER347		0.04	0.4	1.4	19.3	9.5	0.10	Nb 0.5 Cu 0.05	7	510 (74)	655 (95)	35	+20/130	68/96
347Si	EN ISO 14343-A: W 19 9 NbSi AWS/SFA 5.9: ER347Si	TÜV NAKS/ HAKC	0.04	0.7	1.7	19.00	9.8	0.10	Nb 0.6 Cu 0.1 Tot <0.5	7	440 (64)	640 (93)	35	+20/90 -60/75	68/66 -76/55
385	EN ISO 14343-A: W 20 25 5 Cu L AWS/SFA 5.9: ER385	TÜV	0.01	0.4	1.7	20.0	25.0	4.4	Cu 1.5 Tot <0.5		340 (49)	540 (78)	37	+20/120	68/89
2209	EN ISO 14343-A: W 22 9 3 N L AWS/SFA 5.9: ER2209	CE DB TÜV NAKS/ HAKC	0.01	0.5	1.5	22.7	8.5	3.2	N 0.15 Tot<0.5	45	600 (87)	765 (111)	28	+20/100 -20/85 -60/60	68/74 -4/63 -76/44
2307	EN ISO 14343-A: W 23 7 NL	CE	0.01	0.5	1.4	23.2	7.1	3.2	N 0.15 Tot<0.5		560 (81)	730 (106)	32	+20/160 -60/60	68/118 -76/44
2509	EN ISO 14343-A: W 25 9 4 N L AWS/SFA 5.9: ER2594		0.01	0.4	0.4	25.2	9.4	3.9	N 0.24	40	660 (96)	835 (121)	37	-20/200 -50/180	-4/147 -58/132
410NiMo	EN ISO 14343-A: W 13 4 AWS/SFA 5.9: ER410NiMo (mod)		0.02	0.4	0.5	12.4	4.2	0.6	Cu 0.1 Tot <0.5		930 (135)	1000 (145)	17	0/120 -20/120	32/89 -4/89
430LNbTi	EN ISO 14343-A: G Z 18 L Nb Ti		0.01	0.5	0.5	18.5	0.2	0.06	Ti 0.2 Nb Min 0.05 +7x(C+N)		270 (39)	415 (60)	25		

	Description
	Bare, corrosion resistant, chromium-nickel welding rod for welding materials of 29% Cr, 9% Ni type. Good oxidation resistance at high temperatures due to its high content of Cr. Widely used for joining dissimilar steels, especially if one of the components is fully austenitic, and for steels that are difficult to weld, e.g. machine components, tools and austenitic-manganese steels.
	Bare, corrosion resistant, chromium-nickel-molybdenum rod for welding austenitic stainless alloys of 18% Cr, 8% Ni and 18% Cr, 10% Ni, 3% Mo type. Good overall corrosion resistance, particularly to corrosion in acid and chlorinated environments. Low carbon content makes it particularly recommended when there is a risk of intergranular corrosion. Widely used in chemical and food processing industries, as well as in shipbuilding and various architectural structures.
	Bare corrosion resisting chromium-nickel-molybdenium rods for welding of austenitic stainless alloys of 18% Cr, 8% Ni and 18% Cr, 10% Ni, 3% Mo types. Good general corrosion resistance, in particularly the alloy has very good resistance against corrosion in acid and chlorinated environments. Low carbon content makes it particularly recommended where there is a risk of intergranular corrosion. Higher silicon content improves welding properties, such as wetting. Widely used in chemical and food processing industries as well as in shipbuilding and various types of architectural structures.
	Bare corrosion resisting, chromium-nickel-molybdenum rod for welding of austenitic stainless alloys of 19% Cr, 9% Ni, 3% Mo type. Good resistance to general corrosion and pitting, due to its high content of molybdenum. Low carbon content makes it particularly recommended when there is a risk of intergranular corrosion. Used in severe corrosion conditions, such as in petrochemical, pulp and paper industries.
	Bare, corrosion resistant, stabilised, chromium-nickel-molybdenum wire for welding CrNiMo and CrNi stabilised or non-stabilised steels. Good overall corrosion resistance. Stabilised with niobium to improve resistance to intergranular corrosion of weld metal. Higher silicon content improves welding properties such as wetting. Due to stabilisation by niobium, this alloy is recommended for service temperatures up to 400°C (750°F).
	Bare corrosion resisting, chromium-nickel rods for the welding of stabilised austenitic chromium nickel alloys of 18% Cr, 8% Ni type. Rods are stabilised with niobium, which gives good resistance to intergranular corrosion of weld metal. Due to niobium content, this alloy is recommended for use at higher temperatures.
	Bare, corrosion resistant, chromium-nickel rod for welding austenitic chromium nickel alloys of 18% Cr, 8% Ni type. Good overall corrosion resistance. Stabilised with niobium to improve resistance to intergranular corrosion of weld metal. Higher silicon content improves welding properties, such as wetting. Due to niobium content, this alloy is recommended for use at higher temperatures.
	Bare, corrosion resistant welding rod for welding austenitic stainless steels of 20Cr25Ni4.5Mo1.5Cu type. 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 18Cr8NiMo steels.
	Bare, corrosion resistant, duplex welding rods for welding austenitic-ferritic stainless alloys of 22% Cr, 5% Ni, 3% Mo type. 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. Used in a variety of applications across all industrial segments.
	A continous, solid, corrosion-resistent duplex wire for welding austenitic-ferritic stainless alloys of 21% Cr, 1%Ni or 23% Cr, 4% Ni types of lean duplex stainless steel used in civil engineering, storage tanks, containers, etc.
	Bare, corrosion resistant, super duplex rod for welding austenitic-ferritic stainless alloys of 25% Cr, 7% Ni, 4% Mo, low C type. High intergranular corrosion, pitting and stress corrosion resistance. Widely used in applications where corrosion resistance is of the utmost importance, such as pulp and paper, offshore and gas industries.
	Bare welding rod of 420NiMo type alloyed with 13% Cr, 4.5% Ni and 0.5% Mo. Used for welding similar composition martensitic and martensitic-ferritic steels in different applications, such as hydro turbines. Mechanical properties after heat stress relieved 600°C/2h (1110°F/2h).
	A ferritic, stainless, solid wire with low carbon content and excellent welding properties. Contains 18% Cr and is stabilised with Nb and Ti, for welding equivalent and matching steels. The wire should be used when there is a need for very high resistance to corrosion and thermal fatigue.

CORED WIRES—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
- Rutile types are designed for use with Ar/CO_2 or CO_2 shielding gas; 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 the most stringent 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 minimum 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 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 1.2 mm (0.045 in.) types are in excess of three times faster than 3.2 mm (1/8 in.) manual arc electrodes and almost twice as fast as 0.9 mm (0.035 in.) 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 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 1.2 mm (0.045 in.) sizes, and can also be used to advantage for rapid welding of sheet material.

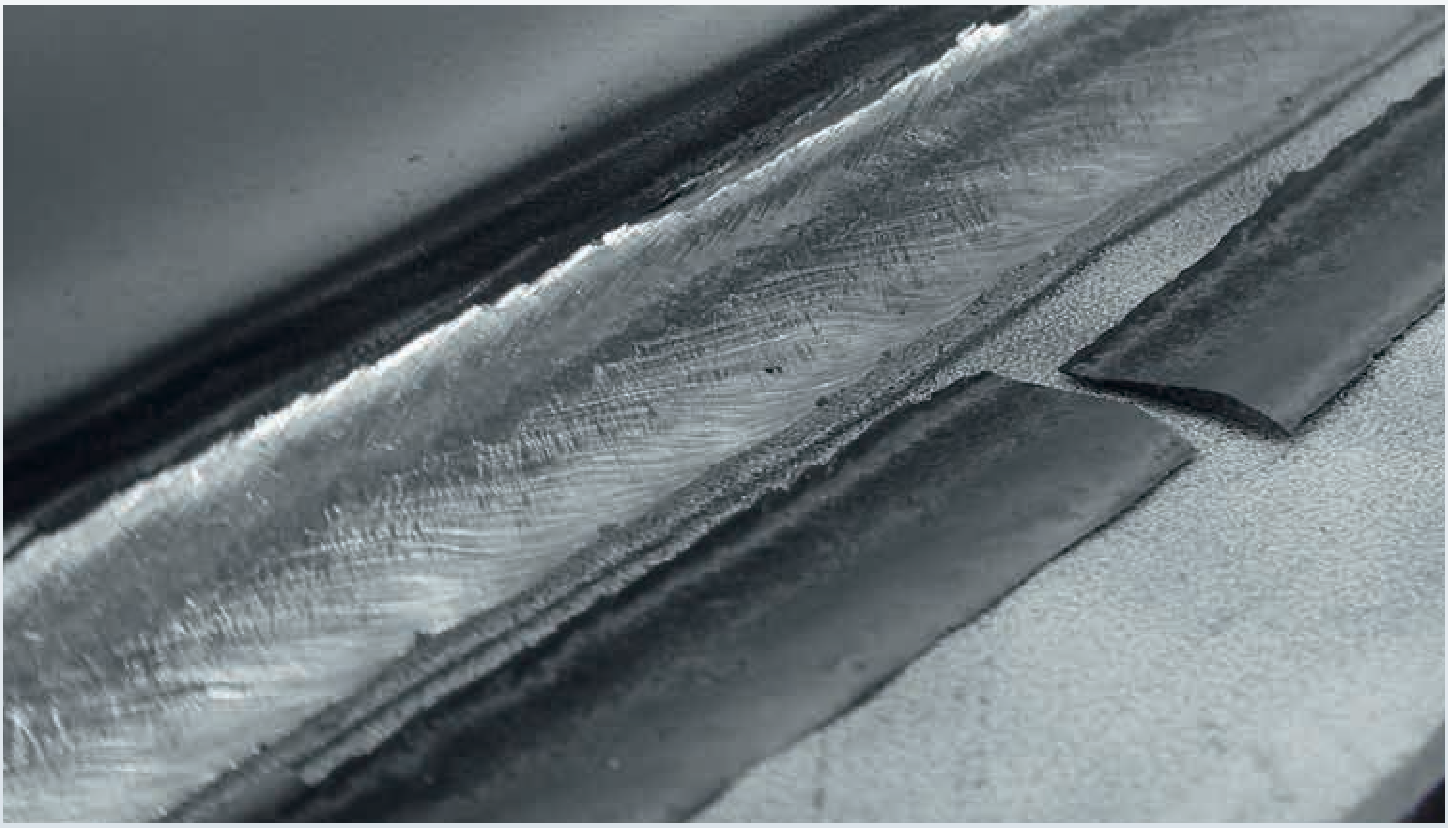
The operability of the Shield-Bright X-tra wires is exceptional combining extreme ease of use, high performance with regard to metal deposition and a weld appearance comparable to the latest generation of manual arc electrodes. As with rutile based C/Mn types, the spray transfer mode is used at all acceptable current levels even down to 100A with the 1.2 mm (0.045 in.) 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.

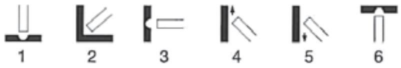
A variety of shielding gases can be used with flux cored types due to the greater tolerance available, although the higher the CO_2 content the higher the carbon content and the lower the alloy and ferrite content.

However, 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.



CORED WIRES—MIG/MAG WELDING.

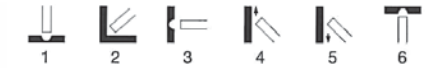
ESAB		Classifications	Approvals	Typical Weld Metal Composition (wt%)							Typical Ferrite	Type	Polarity	Shielding Gas
				C	Si	Mn	Cr	Ni	Mo	Others	FN			
Shield-Bright X-tra Downhand Rutiles	308L	EN ISO 17633-A T 19 9 L R C1 3 T 19 9 L R M21 3 AWS/SFA 5.22 E308LT0-1 E308LT0-4	ABS BV CE CWB DNV-GL LR TÜV	0.02	0.9	1.4	19.6	9.9	0.1	Cu 0.15	8	Rutile	DC+	Ar/15-25%CO2 or CO2
	309L	EN ISO 17633-A T 23 12 L R C1 3 T 23 12 L R M21 3 AWS/SFA 5.22 E309LT0-1 E309LT0-4	ABS BV CE CWB DNV-GL TÜV	0.03	0.8	1.4	24.5	12.5	0.1	Cu 0.10	16	Rutile	DC+	Ar/15-25%CO2 or CO2
	309LMo	EN ISO 17633-A T 23 12 2 L R C1 3 T 23 12 2 L R M21 3 AWS/SFA 5.22 E309LMOT0-1 E309LMOT0-4		0.03	0.8	1.2	23.5	13.5	2.5	Cu 0.10	19	Rutile	DC+	Ar/15-25%CO2 or CO2
	316L	EN ISO 17633-A T 19 12 3 L R C1 3 T 19 12 3 L R M21 3 AWS/SFA 5.22 E316LT0-1 E316LT0-4	ABS CE CWB DNV-GL LR TÜV	0.03	0.6	1.3	18.5	12	2.7		7	Rutile	DC+	Ar/15-25%CO2 or CO2
Shield-Bright All Positional Rutiles	308L	EN ISO 17633-A T 19 9 L P M21 2 T 19 9 L P C1 2 AWS/SFA 5.22 E308LT1-1 E308LT1-4	ABS BV CE CWB DNV-GL LR TÜV	0.03	0.9	1.2	19.0	10.0	0.1	Cu 0.15	7	Rutile	DC+	Ar/15-25%CO2 or CO2
	309L	EN ISO 17633-A T 23 12 L P C1 2 T 23 12 L P M21 2 AWS/SFA 5.22 E309LT1-1 E309LT1-4	ABS BV CE CWB DNV-GL GL LR TÜV	0.03	0.9	1.3	24.0	12.5	0.1	Cu 0.10	16	Rutile	DC+	Ar/15-25%CO2 or CO2
	309LMo	EN ISO 17633-A T 23 12 2 L R C1 2 T 23 12 2 L R M21 2 AWS/SFA 5.22 E309LMOT1-1 E309LMOT1-4	DNV-GL	0.03	0.8	1.2	23.5	13.5	2.5	Cu 0.10	19	Rutile	DC+	Ar/15-25%CO2 or CO2



	Typical Mechanical Properties All Weld Metal					Welding Positions	Description
	R p0.2 MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb		
	410 (59)	580 (84)	40			12	Rutile flux-cored wire designed for downhand and horizontal-vertical (fillet) welding of stainless steels containing 18-20% Cr, 8-12% Ni. In addition to 304L and 308L varieties, it is also suitable for welding stabilised 321 and 347 types. Excellent weldability on conventional non-pulsing power sources, using Ar15-25%CO_2 or pure CO_2 shielding gas.
	480 (70)	600 (87)	35	20/40 -110/32	68/30 -166/23	12	Rutile cored wire designed for 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. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas.
	550 (80)	690 (100)	30			12	Flux-cored, tubular wire for use in downhand and horizontal-vertical positions, producing weld metal of 309+ MoL type composition. The austenitic-ferritic weld deposit has exceptionally high resistance to hot cracking when welding dissimilar steels. Applications of this kind include welding of buffer layers for acid-resistant clad steels and surfacing. Ideally suited to welding mild and low alloy steels to a wide range of stainless steels. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas.
	450 (65)	580 (84)	36	-110/38	-166/38	12	Rutile flux-cored wire designed for downhand and horizontal-vertical (fillet) welding of 316 low carbon type 18-20Cr10-14Ni2-3Mo steels. Composition also ensures that stabilised types can be welded with equal success. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas.
	410 (59)	580 (84)	44			12346	Rutile flux-cored wire designed for all-positional welding of stainless steels containing 18-20%Cr/8-12%Ni. In addition to 304L and 308L varieties, it is also suitable for welding stabilised 321 and 347 types. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding, allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.
	450 (65)	580 (84)	40			12346	Flux-cored, tubular wire depositing weld metal of 309L type for use in all welding positions. Apart from joining these steels, weld metal ferrite content ensures it is suitable for dissimilar applications, as well as joining difficult-to-weld steels. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding, allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.
	480 (70)	620 (90)	30			12346	Rutile cored wire designed for all-positional welding of 316 clad steels on first pass in cladding steels or for welding dissimilar steels such as Mo containing austenitic steels to carbon steels. Excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.

CORED WIRES – MIG/MAG WELDING.

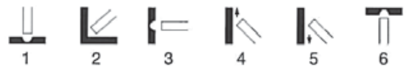
ESAB		Classifications	Approvals	Typical Weld Metal Composition (wt%)							Typical Ferrite	Type	Polarity	Shielding Gas
				C	Si	Mn	Cr	Ni	Mo	Others	FN			
Shield Bright All Positional Wires	316L	EN ISO 17633-A T 19 12 3 L P M21 2 T 19 12 3 L P C1 2 AWS/SFA 5.22 E316LT1-1 E316LT1-4	ABS BV CE CWB DNV-GL LR TÜV	0.03	0.6	1.3	18.5	12.0	2.7	Cu 0.15	8	Rutile	DC+	Ar/15-25%CO2 or CO2
	347	EN ISO 17633-A T 19 9 Nb P M21 2 AWS/SFA 5.22 E347LT1-1 E347LT1-4		0.02	0.8	1.1	19.3	10.0	0.1	Nb 0.4 Cu 0.04	6	Rutile	DC+	Ar/15-25%CO2 or CO2
	2209	EN ISO 17633-A T 22 9 3 N L P M21 2 T 22 9 3 N L P C1 2 AWS/SFA 5.22 E2209T1-1 E2209T1-4		0.03	0.5	1.2	22.5	8.8	3.2	N 0.14 Cu 0.1	35	Rutile	DC+	Ar/15-25%CO2 or CO2
	2594	EN ISO 17633-A T 25 9 4 N L P M21 2 AWS/SFA 5.22 E2594T1-4		0.03	0.6	0.9	25.3	9.7	3.6	N 0.23 Cu 0.1	45	Rutile	DC+	Ar/15-25%CO2
Austenitic Metal Cored	15.30	EN ISO 17633-A T 19 9 L M M12 2 T 19 9 L M M13 2	DB TÜV CE	0.02	0.7	1.3	18.8	9.8	0.1			Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	15.31	EN ISO 17633-A T 19 12 3 L M M12 2 T 19 12 3 L M M13 2	CE DB DNV-GL LR TÜV	0.02	0.7	1.2	17.6	11.6	2.7			Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	15.34	EN ISO 17633-A T 18 8 Mn M M12 2 T 18 8 Mn M M13 2 T 18 8 Mn M M21 2	CE DB TÜV	0.10	0.7	6.7	18.5	8.7	0.1			Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2 or Ar/15-25%CO2
	15.37	EN ISO 17633-A T 22 9 3 N L M M12 2 T 22 9 3 N L M M13 2	CE TÜV	0.02	0.7	0.8	22.2	9.1	3.1	N 0.15		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2



	Typical Mechanical Properties All Weld Metal					Welding Positions	Description
	$R_{p0.2}$ MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CV °C/J	CV °F/ft-lb		
	450 (65)	580 (84)	40	-120/40		12346	Rutile flux-cored wire designed for all-positional welding of 316 low carbon type 18-20Cr10-14Ni2-3Mo steels. Composition also ensures that stabilised types can be welded with equal success. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding, allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.
	430 (62)	600 (87)	55			12346	Rutile cored wire designed for all-positional welding of 321 and 347 stainless steel. Also be used for welding of 302, 304 and sometimes 304L grades. Excellent weldability on conventional non-pulsing power sources with Ar/15-25%CO_2 or pure CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.
	620 (90)	820 (119)	31	-46/58		12346	Rutile flux-cored wire designed for all-positional welding of duplex stainless steels. Ideally suited for all-positional welding of SAF 2205, FAL223, AF22, NK Cr22 and HY Resist 22/5 duplex steels. Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 or pure CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding, allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.
	620 (90)	820 (119)	31	-46/58		12346	Designed for welding 25Cr-9Ni-3Mo-0.2N super duplex stainless steel, e.g. UNS S32750, S32760. Excellent slag removal and bead shape with all position welding for use with Ar/CO_2 gas mixtures (M21). Excellent weldability on conventional non-pulsing power sources, using Ar/15-25%CO_2 shielding gas. Fast freezing slag supports weld metal in positional welding, allowing deposition rates that cannot be equaled by stick electrodes or solid wires up to 4 kg/h (8.8 lb./h) in PF, 3F position.
	340 (49)	550 (80)	45			12	Stainless 308L grade metal cored wire designed for high deposition welding of 301, 302, 304 and 304L grades. Produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in spray mode of arc transfer with Ar/2%O_2 or Ar/2%CO_2 shielding gas.
	416 (60)	575 (83)	37			12	Stainless 316L grade metal cored wire designed for high deposition welding. Produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in spray mode of arc transfer with Ar/2%O_2 or Ar/2%CO_2 shielding gas.
	430 (62)	635 (92)	39			12	Stainless 307 grade metal cored wire designed for high deposition welding of armour steel, austenitic-manganese steels and dissimilar steels. Produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in spray mode of arc transfer with Ar/2%O_2, Ar/2%CO_2 or Ar/15-25%CO_2 shielding gas.
	575 (83)	730 (106)	30			12	Stainless duplex grade metal cored wire. Produces no slag, only small silica islands, and little spatter making it suitable for mechanised and robotic welding. For welding in spray mode of arc transfer with Ar/2%O_2 or Ar/2%CO_2 shielding gas.

CORED WIRES—MIG/MAG WELDING.

ESAB		Classifications	Approvals	Typical Weld Metal Composition (wt%)							Typical Ferrite	Type	Polarity	Shielding Gas
				C	Si	Mn	Cr	Ni	Mo	Others	FN			
Arcaloy Ferritic and Austenitic Metal Cored	MC308L	AWS/SFA 5.22 EC308L		0.02	0.6	1.5	20.0	9.8	0.1		10	Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC309L	AWS/SFA 5.22 EC309L		0.02	0.6	1.5	23.9	12.5	0.1		18	Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC309LSi	AWS/SFA 5.22 EC309LSi		0.03	0.8	1.5	24.0	12.6	0.1		17	Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC316L	AWS/SFA 5.22 EC316L		0.02	0.5	1.4	18.5	12.0	0.1		7	Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC409Ti	AWS/SFA 5.22 EC409		0.02	0.6	0.5	11.6			Ti 0.95		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC409Nb	AWS/SFA 5.22 EC409		0.02	0.6	0.5	11.7			Nb 0.6		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC430LNb	AWS/SFA 5.22 EC430		0.02	0.5	0.4	17.3			Nb 0.4		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC430LNbTi	AWS/SFA 5.22 EC430		0.02	0.5	0.4	17.2			Nb 0.5 Ti 0.5		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC439Ti	AWS/SFA 5.22 EC439		0.02	0.5	0.5	17.5			Ti 0.5		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2
	MC18CrCb	AWS/SFA 5.22		0.02	0.5	0.5	18.2			Nb 0.3 Ti 0.5		Metal Cored	DC+	Ar/2%O2 or Ar/2%CO2



	Welding Positions	Description
	12	Composite metal cored stainless steel wire which has a stainless steel sheath. Used for welding types 301, 302, 304 and 304L. May be used for welding types 321 and 347 if service temperatures do not exceed 260°C (500°F). Higher deposition rate and less penetration compared to solid wire makes it suitable for making butt, fillet and lap welds on gauge material. Higher speeds are also possible compared to solid wire. Low spatter and slag-free welds make this electrode ideal for automatic and robotic welding.
	12	Composite metal cored stainless steel wire designed for welding type 309 wrought or for welding type 304 to mild carbon steel. Recommended for cladding 304 when welded to carbon steel. Higher deposition rate and less penetration compared to solid wire make it suitable for making butt, fillet and lap welds on gauge material. Higher speeds are also possible compared to solid wire. Low spatter and slag-free welds make this electrode ideal for automatic and robotic welding.
	12	Composite metal cored stainless steel wire designed for welding type 304 to mild carbon steel. Addition of Si allows for even more improved wetting during welding. Used for dissimilar welding between the 300 and 400 series stainless steels and mild and low alloys steels. Higher deposition rate and less penetration compared to solid wire make it suitable for making butt, fillet and lap welds on gauge material. Higher speeds are also possible compared to solid wire. Low spatter and slag-free welds make this electrode ideal for automatic and robotic welding.
	12	Composite metal cored stainless steel wire with an addition of molybdenum to help reduce pitting corrosion. Used for welding of thin gauge 316, 316L and sometimes 304 and 304L stainless steels. Higher deposition rate and less penetration compared to solid wire makes it suitable for making butt, fillet and lap welds on gauge material. Higher speeds are also possible compared to solid wire. Low spatter and slag-free welds make this electrode ideal for automatic and robotic welding.
	12	A 12% Cr alloy metal cored electrode designed for joining thin gauge ferritic stainless steels with similar composition metals. MC409TI is stabilised with Titanium to improve corrosion resistance, increase strength at high temperatures and promote a ferrictic microstructure. Produces a smooth spray type material transfer with very minimal spatter and is able to handle poor fit up.
	12	A 12% Cr alloy metal cored electrode designed to join stainless steels with similar composition. Used in similar applications to MC409Ti but where niobium (columbium) is preferred over Ti as stabilising element.
	12	Designed for welding ferritic stainless steels with higher chrome content. Produced with 16% Cr and stabilised with Niobium. Higher chrome content makes it suitable for applications where service temperature and corrosion potential are greater than where 409 series is used. Typically used to join manifolds, catalytic converters, tubing and mufflers.
	12	A 16% Cr alloy metal cored electrode that is dual stabilised with Titanium and Niobium. Typical applications include catalytic converters, manifolds, mufflers, and exhaust systems. The higher chrome content combined with dual stabilisation provides ideal wire for welding 430 grade ferritic stainless steels.
	12	An 18% Cr alloy metal cored electrode stabilised with Titanium. High level of chromium provides additional oxidation and corrosion resistance when welding stainless steel catalytic converters, manifolds, mufflers, and exhaust systems. Also suited for welding parts with poor fit up. Produces a spray type metal transfer with minimal spatter.
	12	An 18% Cr alloy metal cored electrode stabilised with Titanium and Niobium. Designed for welding Armco 18Cr-Cb HP-10TM stainless steels used in catalytic converters, manifolds, mufflers, and exhaust systems. Suited for welding parts with poor fit up. Produces a smooth spray type metal transfer with very minimal spatter.

SUBMERGED ARC WELDING.

Definition.

Submerged arc welding (SAW) is a method in which the heat required to fuse metal is generated by an arc formed by an electric current passing between the electrode and work piece. A layer of granulated mineral material, known as submerged arc welding flux, covers the tip of the welding wire, arc and work piece. There is no visible arc, spark, 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 and Wire Packages.

ESAB delivers fluxes in 25 kg (55 lb.) paper bags, some types in 20 kg (44 lb.) paper bags. Each bag has a polyethylene inlay in order to prevent the flux from moisture pickup in surrounding atmosphere. Palettes of flux bags are protected against moisture by wrap or shrink foil.

For a more robust package, ESAB can supply fluxes in steel buckets with 20-25 kg (44-50 lb.) flux. Buckets have a soft rubber band in the lid which makes them moisture tight. Packing material is fully recyclable and environmentally friendly. The majority of the bag packing material is recycled as paper.

Stainless SAW welding wires are usually delivered on 25 kg (55 lb.) wire baskets. SAW welding wires in diameters 1.6-2.0 mm (1/16-5/64 in.) can also be delivered in 475 kg (1050 lb.) Marathon Pac. Wire is pre-twisted for straight delivery. No decoiling stand needed. All packaging materials are non-returnable, but fully recyclable.

WIRES—SUBMERGED ARC WELDING.

ESAB	Classifications	Typical Wire Composition (wt%)								Typical Ferrite
OK Autrod		C	Si	Mn	Cr	Ni	Mo	N	Others	FN WRC-92
16.97	EN ISO 14343-A: S 18 8 Mn	0.07	0.4	6.5	18.9	8.2				
308L	EN ISO 14343-A: S 19 9 L, AWS/SFA A5.9: ER308L	0.02	0.4	1.9	19.8	9.8		0.05		9
308H	EN ISO 14343-A: S 19 9 H, AWS/SFA A5.9: ER308H	0.05	0.5	1.9	19.8	9.2				
309L	EN ISO 14343-A: S 23 12 L, AWS/SFA A5.9: ER309L	0.02	0.4	1.8	23.2	13.4	0.1	0.05		10
309MoL	EN ISO 14343-A: S 23 12 2 L, AWS/SFA A5.9: (ER309LMo)	0.01	0.4	1.5	21.4	14.6	2.5			
310	EN ISO 14343-A: S 25 20, AWS/SFA A5.9: ER310	0.10	0.4	1.6	25.8	20.7				
310MoL	EN ISO 14343-A: S 25 22 2 N L	0.01	0.1	4.5	25.0	22.0	2.0	0.14		0
312	EN ISO 14343-A: S 29 9, AWS/SFA A5.9: ER312	0.10	0.4	1.6	30.7	8.8				
316L	EN ISO 14343-A: S 19 12 3 L, AWS/SFA A5.9: ER316L	0.01	0.4	1.7	18.2	12.0	2.6	0.04		7
316H	EN ISO 14343-A: S 19 12 3 H, AWS/SFA A5.9: ER316H	0.05	0.4	1.7	19.3	12.5	2.2	0.04		6
316LMn	EN ISO 14343-A: S 20 16 3 Mn N L AWS/SFA A5.9: ER316LMn	0.01	0.4	6.9	20.1	16.5	3.0	0.18		
317L	EN ISO 14343-A: S 18 15 3 L, AWS/SFA A5.9: ER317L	0.01	0.4	1.4	18.9	13.6	3.6	0.05		7
318	EN ISO 14343-A: S 19 12 3 Nb, AWS/SFA A5.9: ER318	0.04	0.4	1.8	18.9	11.5	2.6	0.04	Nb 0.7	11
347	EN ISO 14343-A: S 19 9 Nb, AWS/SFA A5.9: ER347	0.04	0.4	1.4	19.2	9.5		0.05	Nb 0.6	7
385	EN ISO 14343-A: S 20 25 5 Cu L, AWS/SFA A5.9: ER385	0.01	0.4	1.7	20.0	25.0	4.4	0.05	Cu 1.5	
2209	EN ISO 14343-A: S 22 9 3 N L, AWS/SFA A5.9: ER2209	0.01	0.5	1.5	22.7	8.5	3.2	0.17		
2307	EN ISO 14343-A: S 23 7 N L	0.01	0.5	1.4	23.2	7.1		0.15	Cu 0.2	
2509	EN ISO 14343-A: S 25 9 4 N L, AWS/SFA A5.9: ER2594	0.01	0.4	0.4	25.2	9.4	3.9	0.24		
410	AWS/SFA 5.9: ER410	0.12	0.3	0.5	12.2					
410NiMo	EN ISO 14343-A: S 13 4	0.02	0.4	0.5	12.4	4.2	0.6			
420	AWS/SFA 5.9: ER420	0.3	0.3	0.4	13.0					
430	AWS/SFA 5.9: ER430	0.02	0.3	0.4	16.8					

FLUXES — SUBMERGED ARC WELDING.

ESAB		Classifications	Approvals	Typical Weld Metal Composition (wt%)								Typical Ferrite
				C	Si	Mn	Cr	Ni	Mo	N	Others	FN
OK Flux 10.93		ISO 14174: S A AF 2 56 54 DC	CE, DB, NAKS									
in combination with	OK Autrod 16.97	EN ISO 14343-A: S 18 8 Mn	DNV-GL	0.06	1.2	6.3	18	18				
	OK Autrod 308L	EN ISO 14343-A: S 19 9 L AWS/SFA A5.9: ER308L	TÜV DB, CE ABS, BV DNV-GL 308L	<0.02	0.6	1.4	19.5	10				8
	OK Autrod 308H	EN ISO 14343-A: S 19 9 H AWS/SFA A5.9: ER308H		0.05	0.6	1.5	19.9	9.9				
	OK Autrod 309L	EN ISO 14343-A: S 23 12 L AWS/SFA A5.9: ER309L	DNV-GL 309L LR, TÜV CE, ABS	<0.02	0.5	1.3	23	12.5				
	OK Autrod 309MoL	EN ISO 14343-A: S 23 12 2 L AWS/SFA A5.9: (ER309MoL)		0.02	0.5	1.5	20.8	14.5	2.8			
	OK Autrod 310MoL	EN ISO 14343-A: S 25 22 2 N L		0.02	0.1	4	24.5	22	2.1	0.12		
	OK Autrod 312	EN ISO 14343-A: S 29 9 SFA/AWS A5.9: ER312		0.1	0.5	1.5	29	9.5	0.1			
	OK Autrod 316L	EN ISO 14343-A: S 19 12 3 L AWS/SFA A5.9: ER316L	CE, ABS DNV-GL 316L TÜV, DB	<0.02	0.5	1.4	18.0	12.5	2.6			8
	OK Autrod 316H	EN ISO 14343-A: S 19 12 3 H AWS/SFA A5.9: ER316H		0.05	0.6	1.5	19	12.5	2.2			
	OK Autrod 316LMn	EN ISO 14343-A: S 20 16 3 Mn N L AWS/SFA A5.9: ER316LMn		0.02	0.7	5.4	20	15.5	2.5	0.13		0
	OK Autrod 317L	EN ISO 14343-A: S 18 15 3 L AWS/SFA A5.9: ER317L		<0.02	0.5	1.5	18.5	13.5	3.2			
	OK Autrod 318	EN ISO 14343-A: S 19 12 3 Nb AWS/SFA A5.9: ER318	TÜV DB CE	<0.04	0.5	1.2	18.5	12	2.6		Nb 0.3	9
	OK Autrod 347	EN ISO 14343-A: S 19 9 Nb AWS/SFA A5.9: ER347	TÜV DB CE	0.04	0.5	1.1	19.2	9.6			Nb 0.5	8
	OK Autrod 385	EN ISO 14343-A: S 20 25 5 Cu L AWS/SFA A5.9: ER385	TÜV	<0.02	0.5	1.5	19	25	4		Cu 1.5	
	OK Autrod 2209	EN ISO 14343-A: S 22 9 3 N L AWS/SFA A5.9: ER2209	ABS, BV DNV-GL LR, TÜV RINA, CE	0.02	0.5	1.3	22.5	9	3.1	0.17		45
	OK Autrod 2307	EN ISO 14343-A: S Z 23 7 N L		0.02	0.7	1.1	22.5	7.5	0.3	40		
	OK Autrod 2509	EN ISO 14343-A: S 25 9 4 N L SFA/AWS A5.9: ER2594	CE, TÜV	<0.02	0.5	0.4	23.5	10	4.5	0.19	Cu 0.1	40
	OK Autrod 410NiMo	EN ISO 14343-A: S 13 4		0.02	0.4	0.5	11.7	4.1	0.5			

	Typical Mechanical Properties All Weld Metal					Basicity Index	Density	Grain Size		Slag Type	Polarity	Alloy Transfer	Description
	R p0.2 MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb		kg/dm3 (lb/ft3)	mm	in.				
						1.7	~1.1 (~69)	0.25-1.6	0.01-0.062	Basic	DC+	None	Agglomerated basic flux for submerged arc welding of stainless steels, primarily multi-run. Designed for butt and fillet welding of standard austenitic stainless steels and higher alloyed stainless steels. Low Si addition during welding provides good mechanical properties, particularly good impact properties. Very good weldability in 2G position. Works very well on DC current. Single and multi-layer welding of unlimited plate thickness. 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. Suitable for joining duplex 2205 stainless steels, e.g. in chemical tankers.
	400 (58)	600 (87)	45	-20/60	68/44								
	400 (58)	560 (81)	38	+20/100 -60/65 -110/55 -196/40	68/74 -76/48 -166/41 -320/30								
	430 (62)	570 (83)	33	+20/90 -60/70 -110/60 -196/35	68/66 -76/52 -166/44 -320/25								
	400 (58)	600 (87)	38	+20/120	68/89								
	335 (49)	575 (83)	42	+20/120	68/89								
	390 (57)	565 (82)	42	-60/90 -110/75 -196/40	-76/66 -166/55 -320/30								
	410 (58)	600 (87)	44	-60/70 -110/60 -196/40	-76/52 -166/44 -320/30								
	440 (64)	615 (89)	28	+20/80 -60/50	68/59 -76/37								
	440 (64)	600 (87)	42	+20/100 -60/90 -110/40	68/74 -76/66 -166/30								
	455 (66)	635 (92)	35	-60/85 -110/60 -196/30	-76/63 -166/44 -320/22								
	310 (45)	530 (77)	35	+20/80	68/59								
	630 (52)	780 (113)	30	-20/125 -40/110 -60/80	-4/92 -40/81 -76/59								
	560 (81)	730 (106)	35	+20/140 -40/90 -60/60	68/103 -40/66 -76/44								
	640 (93)	840 (122)	28	+20/85	68/63								
	900 (130)	1000 (145)	16	+0/30 -20/30	32/22 -4/22								

FLUXES—SUBMERGED ARC WELDING.

ESAB		Classifications	Approvals	Typical Weld Metal Composition (wt%)							Typical Ferrite
				C	Si	Mn	Cr	Ni	Mo	Others	FN
OK Flux 10.90		ISO 14174: S A AF 2 55 53 MnNi DC									
in combination with	OK Autrod 310	EN ISO 14343-A: S 25 20 SFA/AWS A5.9: ER310		0.07	0.4	3.2	25.5	20	0.02		
OK Flux 10.92		ISO 14174: S A CS 2 57 53	DC/NAKS								
in combination with	OK Autrod 16.97	EN ISO 14343-A: S 18 8 Mn		0.04	1	5	18.8	8.5	0.02		
	OK Autrod 308L	EN ISO 14343-A: S 19 9 L AWS/SFA A5.9: ER308L	TÜV	<0.02	0.9	1	20	10			
	OK Autrod 309L	EN ISO 14343-A: S 23 12 L AWS/SFA A5.9: ER309L		0.02	0.8	1.1	24.1	12.9			
	OK Autrod 316L	EN ISO 14343-A: S 19 12 3 L AWS/SFA A5.9: ER316L	TÜV	0.02	0,8	1	19.1	11.9	2.7		
	OK Autrod 318	EN ISO 14343-A: S 19 12 3 Nb AWS/SFA A5.9: ER318	TÜV		0.5	1.2	18.5	12	2.6	Nb 0.3 Cu 0.2	9
	OK Autrod 347	EN ISO 14343-A: S 19 9 Nb AWS/SFA A5.9: ER347	TÜV	0.04	0.7	0.9	19.8	9.7			9
OK Flux 10.94		ISO 14174: S A AF 2 56 64									
in combination with	OK Autrod 308L	EN ISO 14343-A: S 19 9 L AWS/SFA A5.9: ER308L		0.02	0.5	1.4	20	9.5			11
	OK Autrod 347	EN ISO 14343-A: S 19 9 Nb AWS/SFA A5.9: ER347		0.04	0.5	1	19.6	9.6		Nb 0.5	9
	OK Autrod 2509	EN ISO 14343-A: S 25 9 4 N L AWS/SFA A5.9: ER2594		<0.04	0.5	0.5	25.5	9.5	3.5	N 0.02	50
OK Flux 10.95		ISO 14174: S A AF 2 56 44 Ni									
in combination with	OK Autrod 308L	EN ISO 14343-A: S 19 9 L AWS/SFA A5.9: ER308L		<0.03	0.6	1.4	20	11			5
OK Flux 10.99											
in combination with	OK Autrod 308L	EN ISO 14343-A: S 19 9 L AWS/SFA A5.9: ER308L		0.03	0.3	1.9	19.2	9.8	0.1	N 0.07	6
	OK Autrod 309L	EN ISO 14343-A: S 23 12 L AWS/SFA A5.9: ER309L		0.03	0.4	1.9	22	13	0.03	N 0.09	
	OK Autrod 316L	EN ISO 14343-A: S 19 12 3 L AWS/SFA A5.9: ER316L		0.03	0.4	1.7	18.3	12	2.6	N 0.05	
	OK Autrod 316LMn	EN ISO 14343-A: S 20 16 3 Mn N L AWS/SFA A5.9: ER316LMn		0.03	0.7	8.0	22	18	3.2	N 0.15	

	Typical Mechanical Properties All Weld Metal					Basicity Index	Density	Grain Size		Slag Type	Polarity	Alloy Transfer	Description
	R p0.2 MPa (ksi)	Rm MPa (ksi)	A4* A5** (%)	CVN °C/J	CVN °F/ft-lb		kg/dm3 lb/ft3	mm	in.				
						1.7	~1.0 (~62)			Basic	DC+	Cr, Ni, Mn	Agglomerated aluminate-fluoride-basic flux for welding of 9% Ni steels and high alloyed steels with Ni based wires. Manganese addition reduces risk of hot cracking. Good slag detachability and bead appearance.
	390 (57)	570 (82)	34	+20/85	68/63								
						1.0	~1.0 (~62)	0.25-1.6	0.01-0.062	Neutral	DC+	Cr	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. Gives smooth bead appearance if used for strip cladding with austenitic stainless welding strips. For chemical and petrochemical plants, offshore constructions, pressure vessels, storage tanks, chemical tankers, power generation, nuclear, pulp and paper, civil constructions, transport industries, etc.
	450 (65)	630 (91)	42	+20/60 -20/55 -60/45	68/44 -4/41 -76/33								
	365 (53)	580 (84)	38	-60/60 -196/50	76/44 -166/30								
	400 (65)	520 (91)	30	+20/30	68/22								
	385 (56)	590 (86)	36	-60/55									
	440 (64)	600 (87)	42	+20/100 -60/90 -110/40	68/74 -76/66 -166/30								
	470 (68)	640 (93)	35	+20/65 -60/55 -110/40	68/48 -76/41 -166/30								
						1.9	~1.0 (~62)	0.25-1.6	0.01-0.062	Basic	DC+	Cr	Agglomerated flux for butt welding of stainless steels, primarily multi-run. Low Si addition provides good mechanical properties. Single and multi-layer welding of unlimited plate thickness. Slag is self lifting. Leaves clean and flat welds. For chemical and petrochemical plants, pressure vessels, storage tanks, chemical tankers, etc. Recommended for joining super duplex 2507 stainless steels, e.g. in offshore applications.
	400 (58)	560 (81)	40	+20/85 -60/60	68/63 -76/44								
	455 (66)	620 (90)	38	+20/100 -60/70 -110/50 -196/30	68/74 -76/52 -166/37 -320/22								
	625 (91)	830 (120)	28	+20/90 -60/50	68/66 -76/37								
						2.0	~1.0 (~62)	0.25-1.6	0.01-0.062	Basic	DC+	Ni	Agglomerated flux for submerged arc butt and fillet welding of austenitic stainless steels. Use in applications requiring ferrite content of 3-8% and impact strength at low temperatures. Primarily for multi-run welding. Provides neat weld surfaces and easy slag removal. For chemical, petrochemical plants, offshore constructions, pressure vessels, storage tanks, civil constructions, transport industries, etc.
	400	540	40	+20/88 -60/80 -110/70 -196/50									
						2.5	~1.0 (~62)			Basic	AC, DC+	None	Agglomerated basic flux designed for submerged arc welding process of austenitic and ferritic-austenitic stainless steels, using AC or DC current. Welding in AC provides good mechanical properties and better impact properties. Can be used in DC to weld Ni based alloys with Ni-based wires. High basicity gives better impact values, regardless of current used. Good weldability in 1G and 2G position. Slag is self-lifting or easily detached leaving clean and nice bead appearance.
	400 (58)	560 (81)	36	-20/105 -40/100 -60/90 -196/55	-4/77 -40/74 -76/66 -320/41								
	410 (59)	575 (83)	36	-20/105 -40/100 -60/95 -110/85	-4/77 -40/74 -76/70 -166/63								
	410 (59)	570 (82)	35	-20/110 -40/105 -60/100 -196/70	-4/81 -40/77 -76/74 -320/52								
	420 (60)	630 (91)	40	-60/105 -110/90 -196/55	-76/77 -166/66 -320/41								

STRIPS—SUBMERGED ARC AND ELECTROSLAG STRIP CLADDING.

ESAB	Classifications	Typical Wire Composition (wt%)								Typical Ferrite
OK Band		C	Si	Mn	Cr	Ni	Mo	N	Others	FN
308L	EN ISO 14343-A: B 19 9 L AWS/SFA 5.9: EQ308L	0.015	0.3	1.8	20.0	10.5		0.06		12
309L	EN ISO 14343-A: B 23 12 L AWS/SFA 5.9: EQ309L	0.01	0.4	1.7	23.7	13.3		0.05		15
309L ESW	EN ISO 14343-A: B 22 11 L	0.01	0.2	1.8	21.1	11.0		0.05		15
316L	EN ISO 14343-A: B 19 12 3 L AWS/SFA 5.9: EQ316L	0.01	0.4	1.7	18.5	12.6	2.9	0.05		7
309LMo ESW	EN ISO 14343-A: B 21 13 3 L AWS/SFA 5.9: (EQ309LMo)	0.015	0.2	1.8	20.5	13.5	2.9	0.06		13
317L	EN ISO 14343-A: B 18 15 3 L AWS/SFA 5.9: EQ317L	0.01	0.5	1.3	19.0	14.0	3.6	0.05		
347	EN ISO 14343-A: B 19 9 Nb AWS/SFA 5.9: EQ347	0.02	0.4	1.8	19.5	10.0		0.06	Nb 0.5	11
309LNb	EN ISO 14343-A: B 23 12 L Nb	0.01	0.2	2.0	23.8	12.5		0.03	Nb 0.7	23
309LNb ESW	EN ISO 14343-A: B 22 12 L Nb	0.01	0.2	1.7	21.1	11.0		0.04	Nb 0.6	15
310MoL	EN ISO 14343-A: B 25 22 2 N L	0.02	0.2	4.5	25.0	22.0	2.1	0.13		0
2209	EN ISO 14343-A: B 22 9 3 N L AWS/SFA 5.9: EQ2209	0.015	0.4	1.5	23.0	9.0	3.2	0.15		50
430	EN ISO 14343-A: B17	0.04	0.4	0.7	17.0					

The strip electrodes are delivered in cold rolled condition in 25 kg (55 lb.) or 50 kg (110 lb.) and 100-200 kg (220-440 lb.) coils with an inner diameter of 300 mm (11 13/16 in.). 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.

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 processes 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 60x0.5 mm or 90x0.5 mm, is used as the (usually positive) electrode and an electric arc is formed between the strip and the work piece. 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.

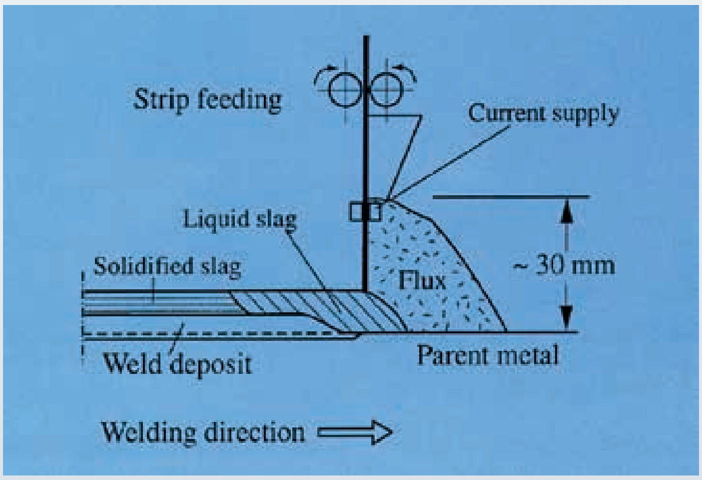
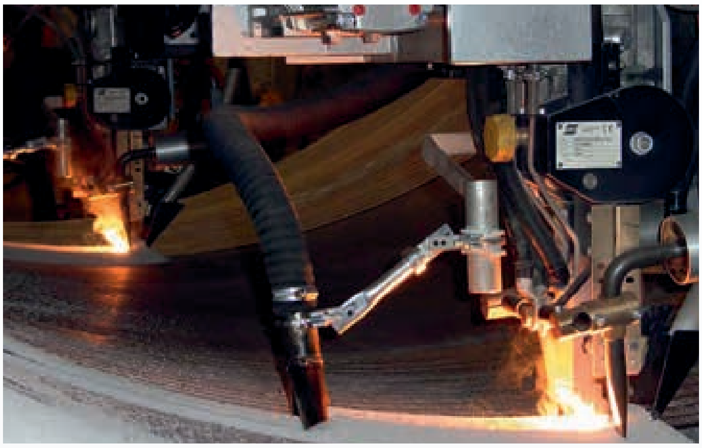


Figure 1.Principles of electroslag strip cladding.



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)
- Required weld deposit chemistry can be achieved by cladding a single layer (usually SAW requires two)
- Lower arc voltage (24-26 V)
- Higher amperage and current density, about 1000–1250A with strips of 60 mm width, corresponding to 33–42A/mm^2; specially developed fluxes for high productivity purposes can be welded with amperage in excess of 2000A which corresponds to a current density about 70A/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 0.5-0.6 kg/kg (0.5-0.6 lb./lb.) strip
- Solidification rate of ESW weld metal is lower, improving degasification and resistance to porosity; oxides can rise easier out of molten pool to the surface; overlay metal is cleaner from metallurgical point of view and less sensitive to hot cracking and corrosion

FLUXES—SUBMERGED ARC AND ELECTROSLAG STRIP CLADDING.

	ESAB	Classifications	Approvals	Typical Wire Composition (wt%)								Typical Ferrite
				C	Si	Mn	Cr	Ni	Mo	N	Others	FN
	OK Flux 10.05	EN 14714: SA CS 2 DC										
in combination with	OK Band 309L (1st layer on mild steel - buffer layer)	EN ISO 14343-A: B 23 12 L AWS/SFA 5.9: EQ309L	TÜV									
in combination with	OK Band 308L (2nd layer on mild steel)	EN ISO 14343-A: B 19 9 L AWS/SFA 5.9: EQ308L		0.02	0.6	1	19	10.5		0.03		6
in combination with	OK Band 316L (2nd layer on mild steel)	EN ISO 14343-A: B 19 12 3 L AWS/SFA 5.9: EQ316L	TÜV	0.02	0.7	1.1	18	13	2.5	0.02		7
in combination with	OK Band 347 (2nd layer on mild steel)	EN ISO 14343-A: B 19 9 Nb AWS/SFA 5.9: EQ347		0.02	0.7	1.1	19	10.5			Nb 0.35	8
	OK Flux 10.07	EN ISO 14174: S A GS 3 Ni4 Mo1 DC										
in combination with	OK Band 430 (2nd layer cladded with OK Band 430 0.5x60mm)	EN ISO 14343-A: B 17		0.05	0.6	0.15	13	4	1			
	OK Flux 10.10	EN 14714: ES A FB 2B 56 44 DC										
in combination with	OK Band 309L ESW (1st layer, welded on 2.25Cr1Mo steel)	EN ISO 14343-A: B 22 11 L		0.03	0.4	1.2	19	10		0.05		4
in combination with	OK Band 309LNb ESW (1st layer, welded on 2.25Cr1Mo steel)	EN ISO 14343-A: B 22 12 L Nb	TÜV	0.03	0.4	1.3	19	10		0.05	Nb 0.4	4
in combination with	OK Band 309LMo ESW (1st layer, welded on 2.25Cr1Mo steel)	EN ISO 14343-A: B 21 13 3 L AWS/SFA A5.9: (EQ309LMo)		0.03	0.4	1.1	18	12.5	2.8	0.04		6
	OK Flux 10.14	EN 14714: ES A FB 2B 56 44 DC										
in combination with	OK Band 309LNb (1st layer, welded on mild steel)	EN ISO 14343-A: B 23 12 L Nb		0.03	0.5	1.6	19.0	10.0		0.02	Nb 0.6	5
in combination with	OK Band 309LMo ESW (1st layer, welded on mild steel)	EN ISO 14343-A: B 21 13 3 L AWS/SFA A5.9: (EQ309LMo)		0.03	0.37	1.38	18.0	12.1	2.5	0.03		6
	OK Flux 10.26	EN ISO 14174: ES A FB 2B 54 91 NiMo DC										
in combination with	OK Band 316L	EN ISO 14343-A: B 19 12 3 L AWS/SFA A5.9: EQ316L		0.02	0.2	1.2	19.0	12.8	2.7	0.05		
	OK Flux 10.27	EN ISO 14174: ES A FB 2B 54 62 NiMo DC										
in combination with	OK Band 309LMo ESW	EN ISO 14343-A: B 21 13 3 L AWS/SFA A5.9: (EQ309LMo)		0.03	0.2	1.0	18.8	13.2	3.4	0.05		
	OK Flux 10. 92	EN 14714: SA CS 2 DC										
in combination with	OK Band 308L (3rd layer on 2.5Cr1Mo steel)	EN ISO 14343-A: B 19 9 L AWS/SFA 5.9: EQ308L	TÜV	0.02	1	0.7	20.6	9.8				12
in combination with	OK Band 316L (3rd layer on 2.5Cr1Mo steel)	EN ISO 14343-A: B 19 12 L AWS/SFA 5.9: EQ316L	TÜV	0.02	0.9	0.7	18.5	12.3	2.8			8
in combination with	OK Band 347 (3rd layer on 2.5Cr1Mo steel)	EN ISO 14343-A: B 19 9 Nb AWS/SFA 5.9: EQ347	TÜV	0.02	1.3	0.7	20.6	9.5				15

	Basicity Index	Density	Grain Size		Slag Type	Polarity	Alloy Transfer	Description
		kg/dm3 (lb/ft3)	mm	in.				
	1.1	~0.7 (~44)	0.25-1.6	0.01-0.062	Slightly Basic	DC+	None	Aluminate basic, agglomerated flux designed for submerged strip cladding with Cr, CrNi, CrNiMo and stabilised stainless strips of AWS EQ300 type. Standard flux for internal overlay welding on mild or low alloyed steel. Very good welding characteristics, gives a smooth bead appearance and easy slag removal. For chemical and petro-chemical plants, pressure vessels, storage tanks, nuclear power generation, pulp and paper, civil constructions, etc.
	1.0	~1.0 (~62)	0.25-1.4	0.01-0.055	Neutral	DC+	Ni, Mo	Neutral Ni and Mo alloying agglomerated flux designed for submerged strip cladding with AWS EQ430 strip producing an overlay weld metal of 14Cr4Ni1Mo and a hardness of 370-420 HB. Produces a ferritic weld metal with enhanced toughness and cracking resistance during service. For cladding on shafts, pistons, continuous cast rolls and other parts of repair and maintenance segment.
	4.0	~1.0 (~62)	0.2-1.0	0.008-0.039	High Basic	DC+	None	High basic, agglomerated flux designed for electroslag strip cladding with austenitic stainless strips. Standard flux for electroslag cladding with various strips, e.g. OK Band 309L ESW. Gives a smooth bead appearance, very good welding properties and easy slag removal. Used for single or multi-layer cladding. Process requires special welding head and power source of at least 1600A. For chemical and petrochemical plants, pressure vessels, storage tanks, nuclear reactor components and power generation.
	4.4	~1.0 (~62)	0.2-1.0	0.008-0.039	High Basic	DC+	None	High basic, agglomerated flux designed for electroslag strip cladding with austenitic stainless strips, especially OK Band 309LNb. Flux for very high productivity strip cladding, up to about 35 cm/min (13.8 in./min). Used for single or multi-layer cladding, smooth bead appearance, very good welding properties and easy slag removal. Process requires water cooled welding head and power source of at least 2400A. For chemical and petrochemical plants, pressure vessels, storage tanks, nuclear reactor components and power generation.
	3.0	~1.2 (~75)			Basic	DC+	Ni, Cr, Mo	High basic, agglomerated Ni, Cr and Mo adding flux designed for electroslag strip cladding with 316L strips gives 316L overlay in first layer. Very good welding characteristics gives a smooth bead appearance and easy slag removal. For chemical industry, marine applications, duct work, water tubes, heat exchangers, paper industry digesters, evaporators, handling and petroleum refining equipment. High basicity gives better impact values, regardless of the current being used. Very good weldability in 1G and 2G position. Slag is self-lifting or easily detached leaving clean and nice bead appearance.
	3.1	~1.2 (~75)			Basic	DC+	Ni, Cr, Mo	High basic, agglomerated Ni, Cr and Mo adding flux designed for electroslag strip cladding with ESAB 309LMo ESW strips gives 317L overlay in first layer. It has a smooth bead appearance, very good welding properties and easy slag removal. Suitable for special applications like flue gas desulfurization scrubber systems chemical and petrochemical processing equipments and pulp and paper plants, etc.
	1.0	~1.0 (~62)	0.25-1.6	0.01-0.062	Neutral	DC+	Cr	Neutral, agglomerated Cr compensating flux designed for strip cladding, butt and fillet welding of stainless and corrosion resistant steel types with AWS ER300 type wires. Works well on DC current for single and multi-layer welding of unlimited plate thickness. Good welding characteristics and easy slag removal. Gives a smooth bead appearance if used for strip cladding with austenitic stainless welding strips. For chemical and petrochemical plants, offshore constructions, pressure vessels, storage tanks, chemical tankers, power generation, nuclear, pulp and paper, civil constructions, transport industries, etc.

FACTS ABOUT STAINLESS STEELS.

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

Stainless Definition.

Stainless is a term coined early in the development of 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. 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. For example, over a period of years, a stainless steel knife can literally be worn away by daily use and by being resharpened, 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. Stainless steels offer a remarkable range of mechanical properties and corrosion resistance and are produced 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. 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 ordinary austenitic or duplex types thanks to further additions of chromium, molybdenum and nitrogen. Super-martensitic steels have a very low carbon content greatly improving weldability. Heat and creep resistant versions of many steels are also available. These have slightly modified composition and when intended for creep applications in particular a somewhat higher carbon content.

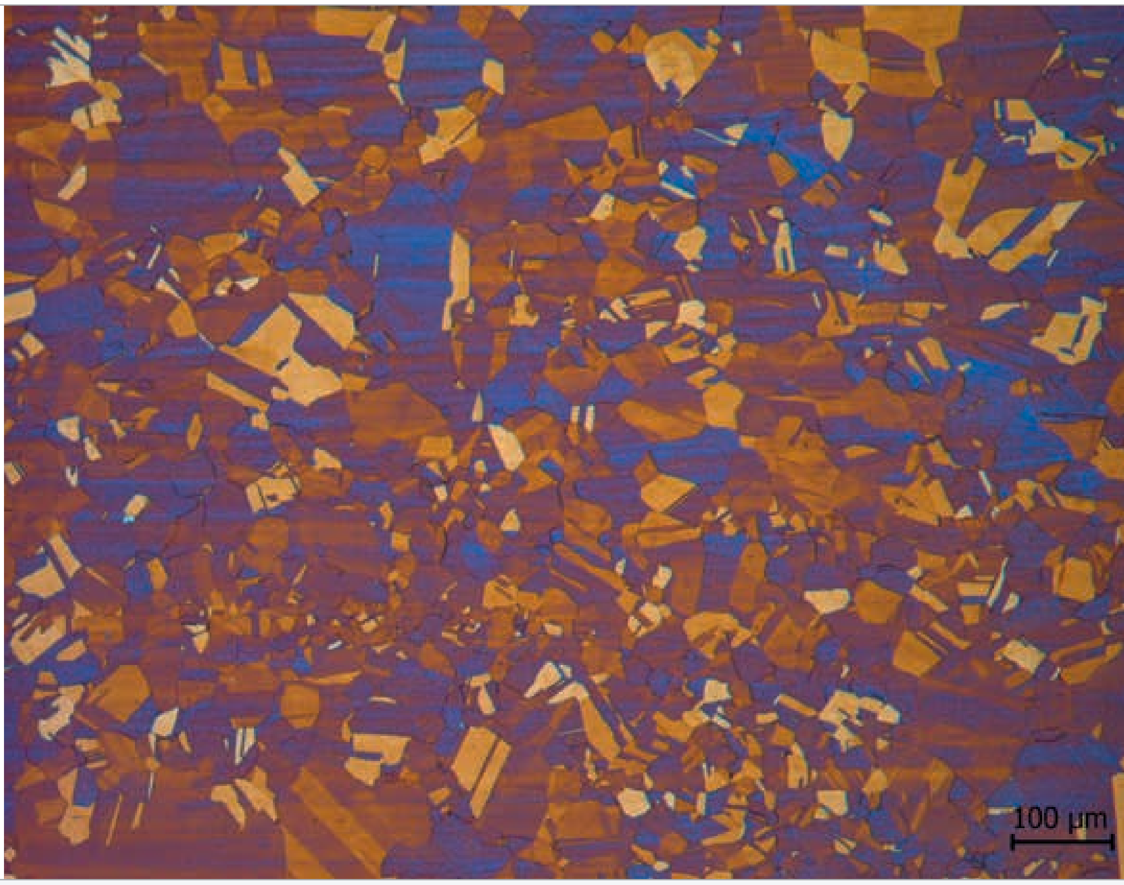
Table 1. Main Stainless Steel Types

Type	Standard Grades Chemical Composition (%)	Special Grades	Applications
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 and 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, Stabilization with Nb, Ti, Sometimes Cu, N Improved 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*


ESAB
ESAB

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 (1/8 in.) 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. Super-martensitic 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 super-martensitic 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 super-austenitic. 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 super-austenitic steels.

The steels are normally supplied with a single phase austenitic structure. However, ferrite can form in the weld metal and in the HAZ during welding. 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 transform into sigma phase at high temperatures easier than austenite. 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. 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 super-duplex 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. Heat input too low leads to a high cooling rate and high ferrite levels. Heat input too high can result in precipitation of deleterious phases in particular in the highly alloyed super-duplex grades. In both cases, toughness and corrosion resistance will suffer.

Literature.

EN 1011-3, 2000, Welding – Recommendations for welding of metallic materials – Part 3: Arc welding of stainless steels.

CORROSION.

Stainless Steels.

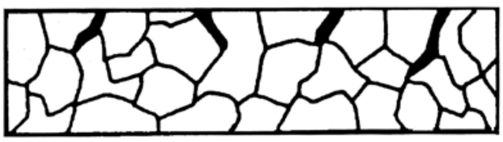
A very thin layer of chromium-rich oxide film, which is formed spontaneously on the surface in the presence of oxygen, protects stainless steels against corrosion. However, stainless steels cannot be considered to be indestructible. The passive state can be broken down under certain conditions and corrosion can result as briefly discussed below. It is 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 of 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 Cr and Mo content 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 (930-1560°F). 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.

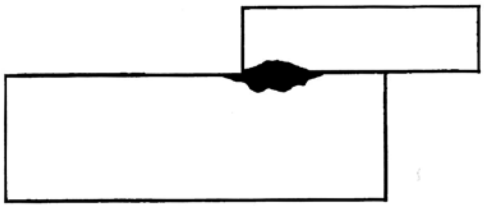
This is a type of localised corrosion, which is highly destructive, ultimately resulting in holes. Pitting attack in stainless steel is most common in neutral or acidic chloride containing environments. The resistance against pitting improves with increasing Cr, Mo and N contents. A pitting resistance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

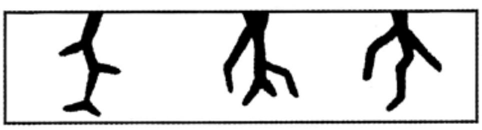
Crevice Corrosion.

Crevice corrosion is a localised corrosion which occurs in narrow crevices under the same conditions as pitting. 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 cracks 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 seldom found in solutions below 60°C (140°F). Ferritic and duplex stainless steels are generally very resistant to SCC and increased Ni and Mo contents improve the resistance of austenitic grades.



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.

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:

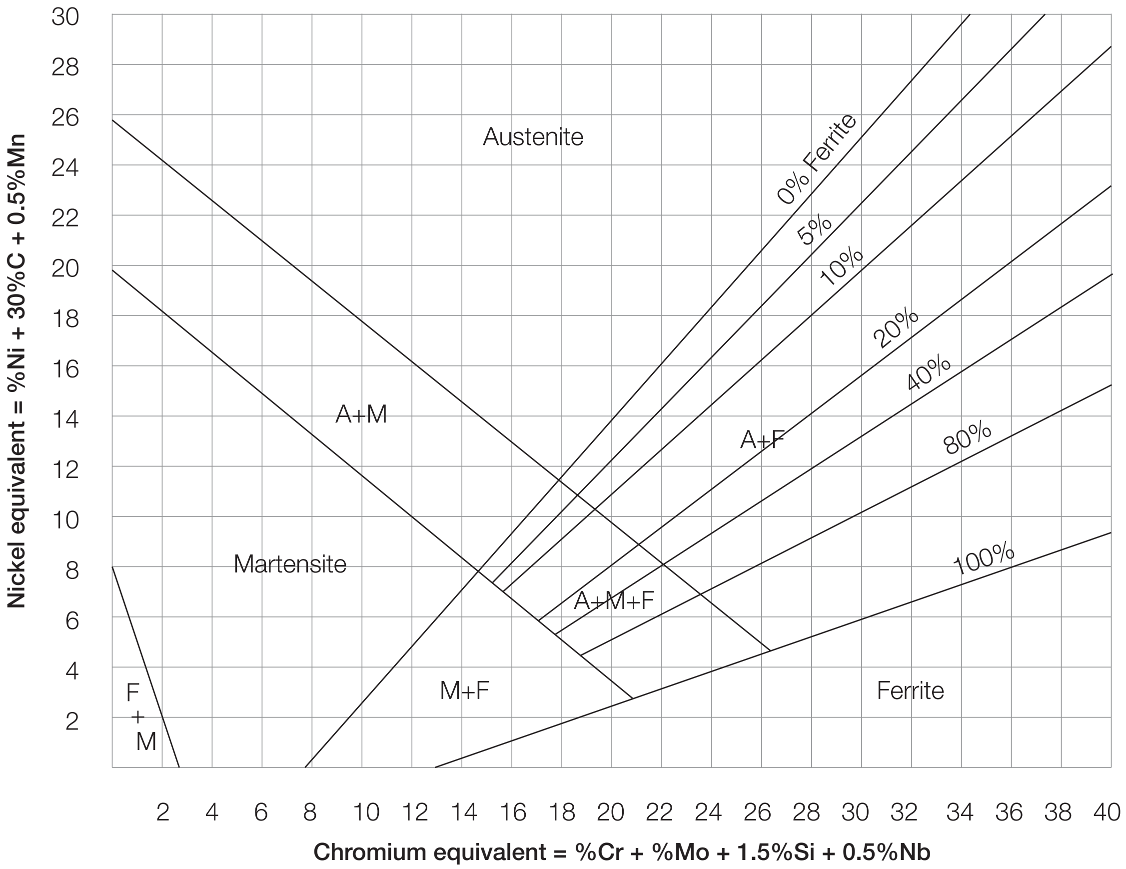
(a) Point counting techniques
(b) Magnetic methods

Point counting gives a ferrite content in ferrite percentage (sometimes denominated FP). Magnetic methods takes advantage of the different magnetic properties of ferrite and austenite with ferrite being ferromagnetic; 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.

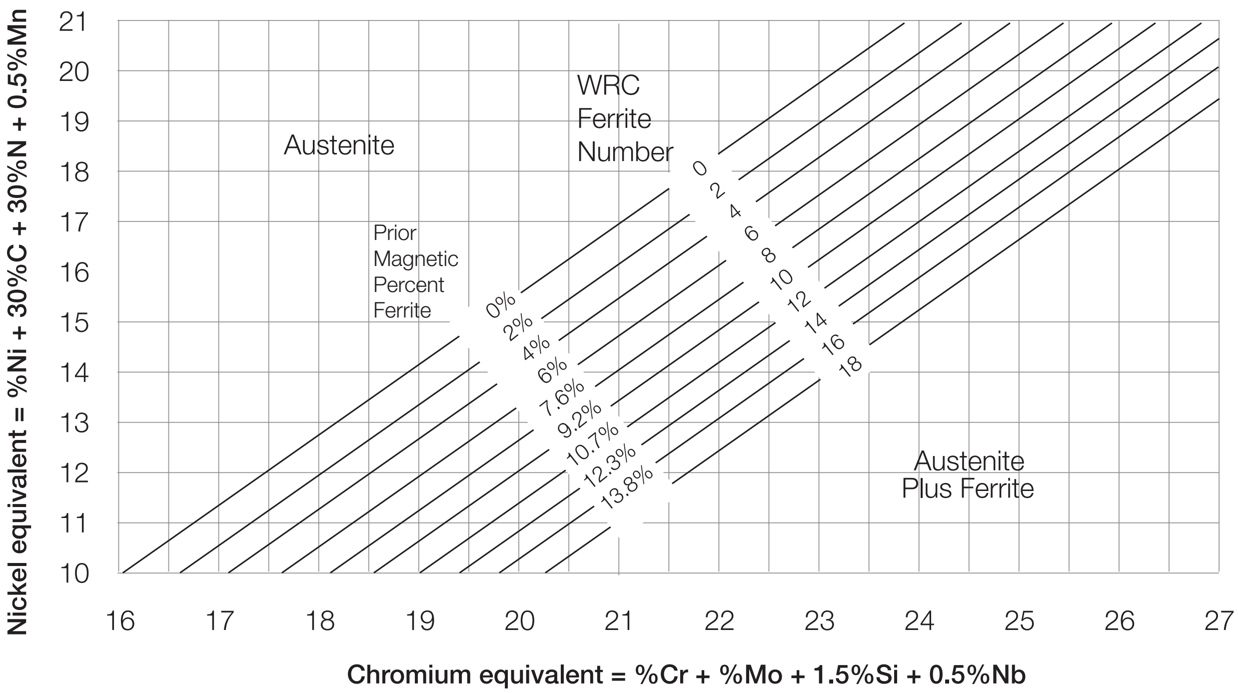
a) Point counting involves direct microscopic measurement on suitably prepared specimens and gives the ferrite content in ferrite percentage. This is a destructive method since a polished and etched metallographic section is required. It cannot readily be used on completed welded fabrications, but can 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 relatively slow and labor 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., MagneGage) or utilize 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. Handheld 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.

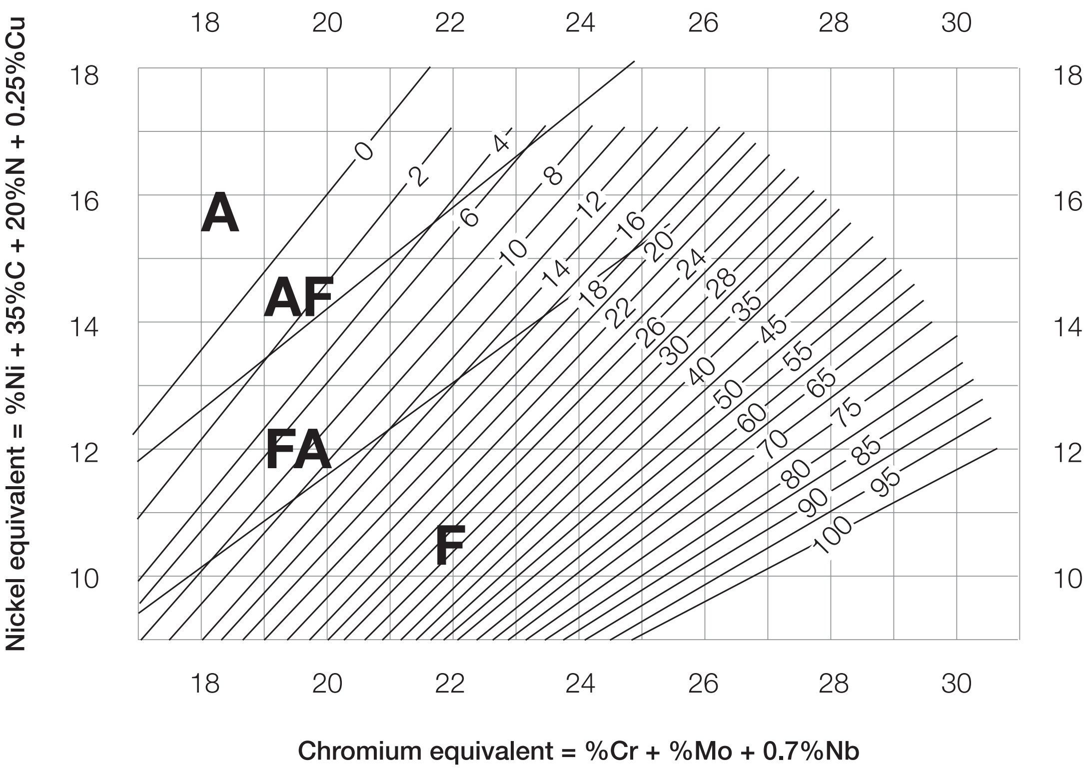
The Schaeffler Diagram

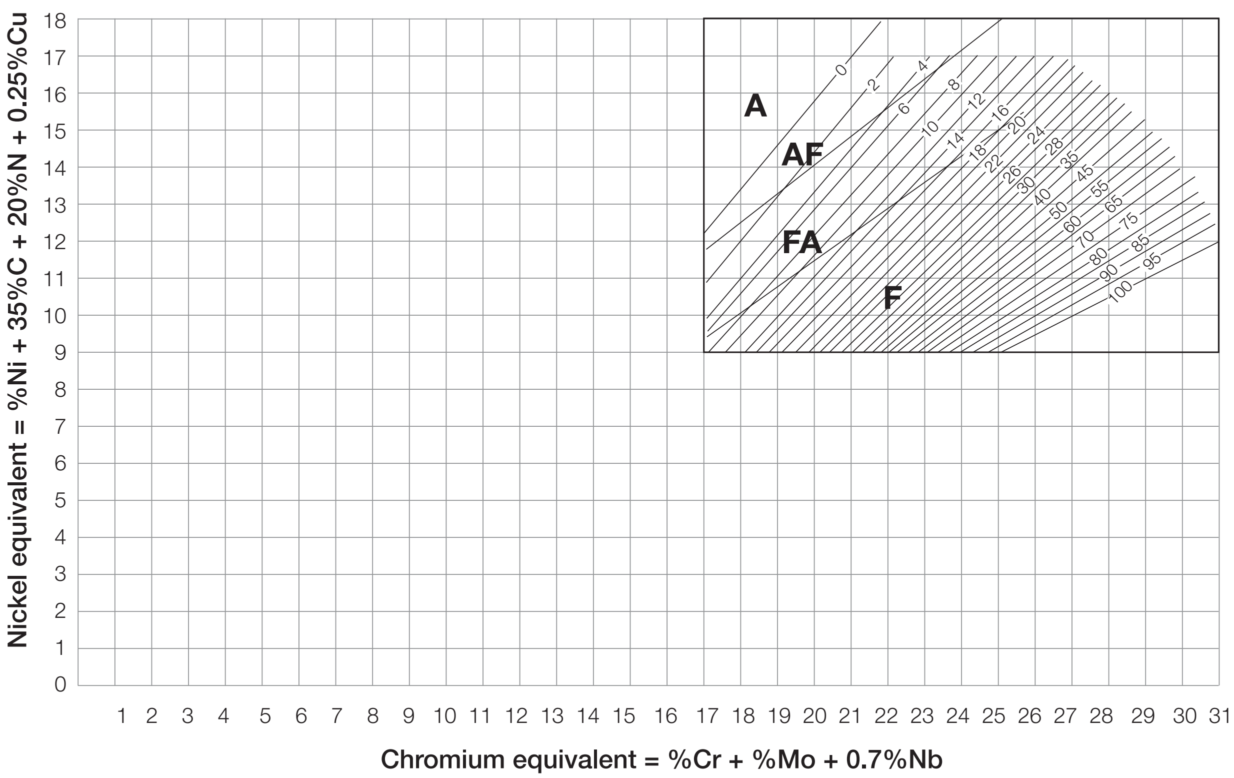


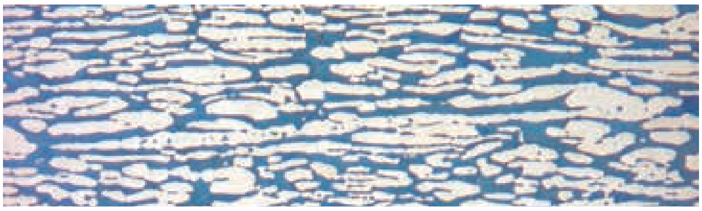
The DeLong Diagram



WRC-1992 Diagram







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 (page 56), now more than fifty years old, is well outdated for ferrite prediction in stainless steel welds and was followed by the DeLong Diagram (page 56) recognising the importance of nitrogen content. The most widely used predictive diagram, and the one recognised by the ASME code since 1995 is the WRC-1992 Diagram (page 57). 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 (e.g. 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-1992 Diagram (page 57) has a possibility of error on 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 about ±20% of the measured value should be expected between different laboratories when testing real welds

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- ISO TR 22824: 2003, Welding consumables – Predicted and measured FN in specifications – A position statement of the experts of IIW Commission IX, ISO, Geneva, Switzerland.
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STORAGE AND HANDLING.

ELECTRODES.

Storage.

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

- 5-15°C (40-59°F): max. 60% RH
- 15-25°C (59-77°F): max. 50% RH
- >25°C (>77°F): max. 40% RH

At low temperatures, maintain low relative humidity by keeping storage temperature at least 10°C (50°F) above 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 moisture content, electrodes should be redried according to instructions. Use quivers for intermediate protection.

Handling VacPac™ Electrodes.

VacPac electrodes are to be stored below 50°C (120°F) and require no redrying before use, provided 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 redry 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 redry electrodes exposed to the atmosphere in an opened VacPac™ 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. Relative humidity and temperature should be monitored and temperature should not fall below the dew point. To avoid condensation, 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. Avoid hydrogen containing substances, such as oil, grease, corrosion and hygroscopic substances. Storage must be adequate to prevent damage.

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

FLUX.

Recommendations for OK Flux.

ESAB agglomerated fluxes 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.

Packaging.

ESAB delivers fluxes in 25 kg (55 lb) paper bags, some types in 20 kg (44 lb.) paper bags. Each bag has a polyethylene inlay to prevent moisture pickup from the surrounding atmosphere. The packing material is fully recyclable and therefore environmentally friendly. The majority of the packing material is recycled as paper.

Fluxes can also supplied in steel buckets containing 20 or 25 kg (44 or 55 lb) . The buckets are moisture tight and resealable. They have a sealing gasket in the lid allowing the redrying of the flux to be avoided.

Storage.

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

- Temperature: 20+/-10°C (68+/-10°F)
- Relative humidity: not exceeding 60%
- Fluxes should 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 (300+/-25°F)
- Remaining flux from open bags should be placed at a temperature of 150+/-25°C (300+/-25°F)

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, e.g. 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 (2 in.) , as follows: 2-4h/300+/-25°C (2-4h/570+/-25°F Redried flux, not immediately used, must be kept at 150+/-25°C (300+/-25°F) before use.

JOINING OF DISSIMILAR STEELS.

Different types of stainless steels can normally be welded to one another without difficulty. It is 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.

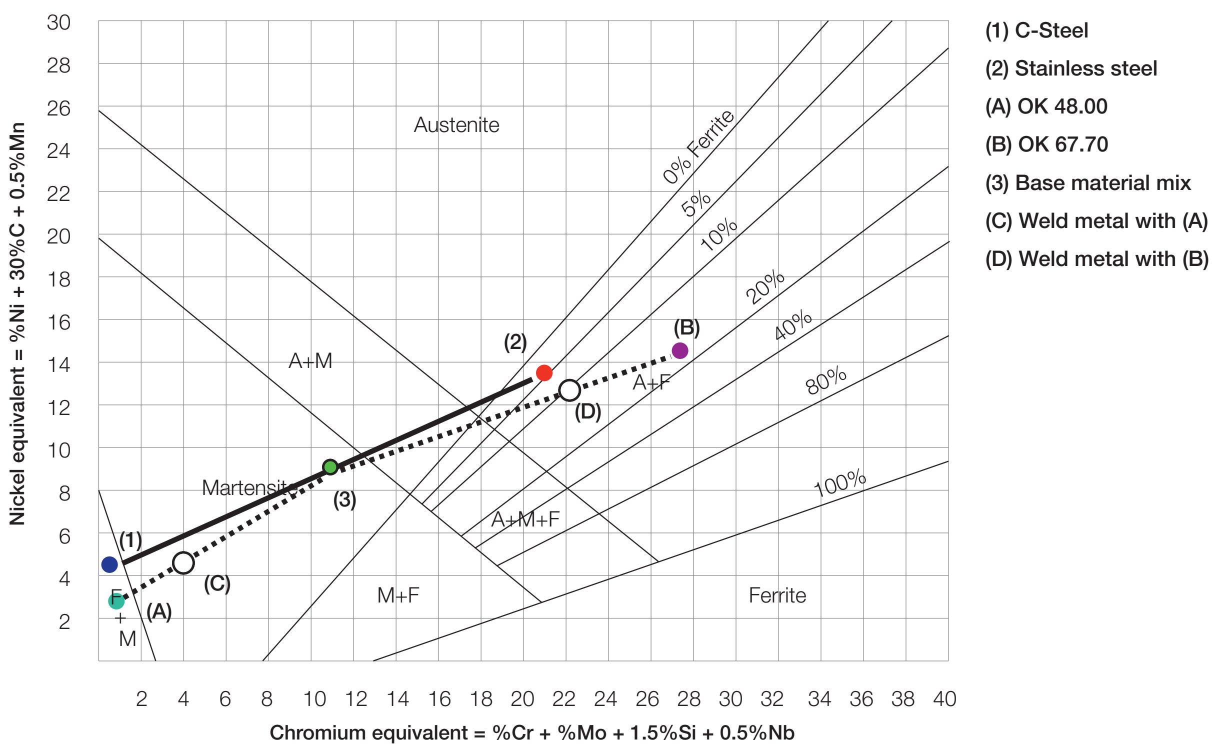
Stainless steels can also be welded to mild or low alloy steels with excellent results if the steel has a reasonable weldability and if certain straightforward guidelines for the avoidance of cracking are followed. The same basic metallurgical considerations apply also to cladding of mild or low alloy 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 unfavorable 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 18Cr8Ni6Mn. Ni base fillers should be used for service temperatures above approximately 350-400°C (660-750°F) to minimise carbon migration into the weld. A diagram 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. Below illustrates the joining of mild steel and 18Cr12Ni3Mo type stainless steel.



Example.

Prediction of weld metal microstructure of a dissimilar joint between a mild steel (1) and a stainless steel of composition 18Cr12Ni3Mo (2) welded with either an unalloyed consumable (A: OK 48.00) or an overalloyed stainless electrode (B: OK 67.70).

Step 1: 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. A lower preheat can often be tolerated when an austenitic stainless or Ni base filler is used.

A PWHT in the range 500-700°C (930-1290°F), 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 common, for example, in cladding of low alloy steels, when a PWHT is required.

JOINING OF DISSIMILAR STEELS — REFERENCE CHART.

BASE	446	440C	440B	440A	431	430	420	414	410	405	403	348	347	330	321	317L
201	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
202	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
301	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
302	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
302B	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
304	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
304L	310	309	309	309	309	309	309	309	309	309	309	308L	308L	312 309	308L	308L
305	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
308	310	309	309	309	309	309	309	309	309	309	309	308	308	312 309	308	308
309	310	309	309	309	309	309	309	309	309	309	309	308 347	308 347	312 309	308 347	308
309S	310	309	309	309	309	309	309	309	309	309	309	308 347	308 347	312 309	308 347	316
310	309 310	309	309	309	309	309	309	309	309	309	309	308 347	308 347	312 310	308	317L
310S	309 310	309	309	309	309	309	309	309	309	309	309	308 347	308 347	312 310	308	317L
314	309 310	309	309	309	309	309	309	309	309	309	309	308	308	312 310	308	317
316	310	309	309	309	309	309	309	309	309	309	309	308 316	308 16-8-2	312 309	308	316
316L	310	309	309	309	309	309	309	309	309	309	309	316L	316L	312 309	308L	316L
317	310	309	309	309	309	309	309	309	309	309	309	308L 16-8-2	308L 16-8-2	312 309	308	317
317L	310	309	309	309	309	309	309	309	309	309	309	308L	308L	312 309	308L 347	317L
321	310	309	309	309	309	309	309	309	309	309	309	347	347	312 309	347	
330	312	312	312	312	312	312	312	312	312	312	312	312 309	312 309	330		
327	309	309	309	309	309	309	309	309	309	309	309	347	347			
348	309	309	309	309	309	309	309	309	309	309	309	348				
403	410	410	410	410	410	430	410	410	410	410	410					
405	410	410	410	410	410	430	410	410	410	410						
410	410	410	410	410	410	430	410	410	410							
414	410	410	410	410	410	430	410	309								
420	430	420	420	420	410	410	420 410									
430	430	430	430	430	430	430										
431	309 310	309	309	309	309											
440A	309 310	309	309	309												
440B	309 310	309	309													
440C	309 310	309														
446	312 310															

317	316L	316	314	310S	310	309S	309	308	305	304L	304	302B	302	301	202	201
308	308	308	308 312	308	308	308	308	308	308	308	308	308	308	308	308	308
308	308	308	308 312	308	308	308	308	308	308	308	308	308	308	308	308	
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308	308	308	308 312	308	308	308	308	308								
309	309 316	309	309 312	309	309	309	309									
316	309	309 316L	309 312	309	309	309										
317	316	316	310 312	310	310											
317	316	316	310 312	310												
317	316	316	310 312													
316	316	316														
316	316L															
317																

This chart should be used as a reference only, the actual application should dictate the alloy choice. The listed filler metal suggestions should be adequate for the joining of the listed stainless steel alloys, this does not mean the other filler metal alloys are not recommended or of less quality.

This chart does not indicate welding procedure. Some stainless steels require preheat while others should not have a preheat. Some welds require a buttering layer or other more rigid procedure.

For more inforamtion please refere to the ESAB Welding Guide for Joining Disilimilar Metals or contact your local ESAB representative.

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