Welding wire

Features

- **Consumables for welding stainless steels and nickel-based alloys**
- **Welding wire for optimum corrosion properties**
- **MIG/MAG (GMAW)**
- **TIG (GTAW)**
- **Submerged arc (SAW)**

Product range

Avesta Welding supplies solid welding wire for MIG/MAG, TIG and submerged arc welding of ferritic, martensitic, duplex and austenitic stainless steels, as well as nickel base alloys. The product range also encompasses welding wire for dissimilar welds between, for example, stainless steel and mild steel, or stainless steel and nickel base alloys. All wires are available manufactured to the requirements set forth by the nuclear power industry in ASME code section III and KTA 1408.

General characteristics

- MIG/MAG is a flexible and fast method for semi- or fully automatic welding. Welding can be performed in all positions and a normal plate thickness would be between 2 and 10 mm. Pulsed arc welding offers the best flexibility and is particularly suitable when high alloyed stainless and nickel base fillers are used.
- TIG welding produces a deposit with excellent surface quality and impact strength. The method is widely used for welding thin walled pipe/tube (0.5–5 mm) in all positions, or for root runs in thicker gauges.
- SAW is a high productivity method for welding thicker materials in the horizontal position. Welding is best performed using an agglomerated neutral or slightly basic welding flux, such as Avesta 801, 805 or 807. SAW requires relatively high heat inputs, which should be considered, especially when welding fully austenitic steels.

Wire types and designations

Wire type EN 12072	Avesta Welding designations
Martensitic	248 SV
Austenitic	308L-Si/MVR-Si, 308L/MVR, 308H, 347-Si/MVNb-Si, 347/MVNb, 316L-Si/SKR-Si, 316L/SKR, 318-Si/SKNb-Si, 318/SKNb, 317L/SNR
Austenitic-ferritic	2304, 2205, 2507/P100
Fully austenitic	904L, P12, P12-0^{Nb}, P16, P54
Special types	307-Si, 309L-Si, 309L, 309L-HF, P5, P7, P10
Heat resisting	309-Si, 310, 253 MA, 353 MA

Weld metal composition

Standard designations

Wire	MIG	TIG	SAW	Chemical composition, typical values, % C	Si	Mn	Cr	Ni	Mo	Other	Ferrite* typical	EN 12072/18274	AWS** A5.9/A5.14
248 SV	x	x	x	0.02	0.35	1.3	16.0	5.5	1.0		10 %	–	–
308L-Si/MVR-Si	x	x		0.02	0.85	1.8	20.0	10.5			11 FN	19 9 L Si	ER308LSi
308L/MVR	x	x	x	0.02	0.40	1.7	20.0	10.0			8 FN	19 9 L	ER308L
308H	x	x	x	0.05	0.40	1.8	20.0	9.0			10 FN	19 9 H	ER308H
347-Si/MVNb-Si	x	x		0.05	0.85	1.2	19.5	10.0		Nb >12xC	10 FN	19 9 Nb Si	ER347Si
347/MVNb		x	x	0.04	0.40	1.3	19.5	9.5		Nb >12xC	6 FN	19 9 Nb	ER347
316L-Si/SKR-Si	x	x		0.02	0.85	1.7	18.5	12.0	2.6		9 FN	19 12 3 L Si	ER316LSi
316L/SKR	x	x	x	0.02	0.40	1.7	18.5	12.0	2.6		8 FN	19 12 3 L	ER316L
318-Si/SKNb-Si	x	x		0.04	0.85	1.3	19.0	12.0	2.6	Nb >12xC	10 FN	19 12 3 Nb Si	–
318/SKNb		x	x	0.04	0.40	1.3	19.0	12.0	2.6	Nb >12xC	8 FN	19 12 3 Nb	ER318
317L/SNR	x	x	x	0.02	0.40	1.7	19.0	13.5	3.5		9 FN	19 13 4 L	ER317L
2304		x	x	0.02	0.40	0.5	23.0	7.0	<0.5	N 0.14	40 FN	–	–
2205	x	x	x	0.02	0.50	1.6	23.0	8.5	3.1	N 0.17	50 FN	22 9 3 L N	ER2209
2507/P100	x	x	x	0.02	0.35	0.4	25.0	9.5	4.0	N 0.25	50 FN	25 9 4 L N	–
904L	x	x	x	0.01	0.35	1.7	20.0	25.5	4.5	Cu 1.5	0 FN	20 25 5 Cu L	ER385
P12	x	x	x	0.01	0.10	0.1	22.0	65.0	9.0	Nb 3.6 Fe <1	0 FN	NiCr22Mo9Nb	ERNiCrMo-3
P12-0[Nb]	x	x	x	0.01	0.10	0.1	22.0	65.0	9.0	Nb <0.1 Fe <1	0 FN	–	–
P16	x	x	x	0.01	0.10	0.2	25.0	60.0	15.0	Nb <0.1 Fe <1.0	0 FN	NiCr25Mo16	–
P54	x	x		0.02	0.20	5.1	26.0	22.0	5.5	N 0.35 Cu 0.9	0 FN	–	–
307-Si	x	x		0.09	0.80	7.0	19.0	8.0			0 FN	18 8 Mn Si	–
309L-Si	x	x		0.02	0.80	1.8	23.5	13.5			13 FN	23 12 L Si	ER309LSi
309L	x	x	x	0.02	0.40	1.8	23.5	14.0			11 FN	23 12 L	ER309L
309L-HF			x	0.02	0.35	1.7	24.0	13.0			16 FN	23 12 L	ER309L
P5	x	x	x	0.02	0.35	1.5	21.5	15.0	2.7		9 FN	23 12 2 L	(ER309LMo)
P7	x	x	x	0.11	0.45	1.9	30.0	9.5			60 FN	29 9	ER312
P10	x	x		0.03	0.10	2.9	20.0	73.0		Nb 2.5 Fe <2	0 FN	NiCr20Mn3Nb	ERNiCr-3
309-Si	x	x		0.09	0.90	1.8	23.0	13.0			9 FN	22 12 H	ER309Si
310	x	x		0.12	0.35	1.6	25.5	21.0			0 FN	25 20	ER310
253 MA	x	x	x	0.07	1.60	0.6	21.0	10.0		N 0.15 REM	9 FN	–	–
353 MA	x	x	x	0.05	0.85	1.6	27.5	35.0		N 0.15 REM	0 FN	–	–

* Ferrite content measured in all weld metal. FN 0–18 according to Schaeffler-DeLong, FN >18 according to WRC-92.
** Parentheses indicate some minor deviations to AWS requirements.

Mechanical properties, typical values (MIG)

Approvals (MIG, TIG, SAW)

Wire	$R_{p0.2}$ N/mm²	R_m N/mm²	Elongation A5 %	Impact strength KV, J +20°C	–40°C	–196°C	Hardness Brinell	TÜV	DNV
248 SV**	460	840	23	80	–	–	260		
308L-Si/MVR-Si	420	600	36	110	–	60	200	MT	MT
308L/MVR*	410	580	36	85	–	35	200	MTS (x)	MTS (801)
308H	400	610	37	95	–	–	210	M	
347-Si/MVNb-Si	430	620	36	100	90	–	210	MT	
347/MVNb*	450	640	34	60	–	–	220	MTS (801)	
316L-Si/SKR-Si	400	600	36	110	–	50	210	MT	MT
316L/SKR*	430	570	36	80	–	35	210	MTS (x)	MTS (x)
318-Si/SKNb-Si	420	600	33	85	80	–	220	MT	
318/SKNb*	490	660	30	50	–	–	220	TS (801)	
317L/SNR	420	630	31	85	–	–	200		
2304*	480	650	25	100	–	–	260	S (805)	
2205	550	770	30	150	110	–	230	MTS (805)	MTS (805)
2507/P100	570	830	29	140	–	–	280	T	
904L	340	570	38	130	–	100	170	MTS (805)	
P12	480	750	42	170	150	–	220	MT	
P12-0^{Nb}	380	630	36	240	–	–	210		
P16	470	700	33	120	–	–	220		
P54	480	750	35	90	–	–	220		
307-Si	470	710	42	120	110	–	220	MT	
309L-Si	400	600	32	110	–	–	200	MT	
309L	380	580	30	120	–	–	200	MT	
309L-HF*	400	550	36	100	–	–	200		S (x)
P5	390	610	31	75	60	–	210	MT	MTS (x)
P7	560	750	25	40	–	–	240		S (801)
P10	410	660	33	–	–	–	200		
309-Si	430	640	34	90	–	–	200		
310	360	570	35	120	–	–	210		
253 MA	440	680	38	130	–	–	210		
353 MA	320	590	43	160	–	–	200		

* Welded with submerged arc wire.
** Annealed at 590°C for 4 hours.

(x) Approved with both Flux 801 and 805.
M = MIG, T = TIG, S = SAW.

For welding the following steels

EN	ASTM	Outokumpu steel grade	Recommended wire type
1.4418	–	248 SV	248 SV
1.4301 1.4307 1.4311 1.4541	304 304L 304LN 321	4301 4307 4311 4541	308L-Si/MVR-Si 308L/MVR 308H
1.4541 1.4550	321 347	4541 –	347-Si/MVNb-Si 347/MVNb
1.4436 1.4432 1.4429 1.4571	316 316L S31653 316Ti	4436 4432 4429 4571	316L-Si/SKR-Si 316L/SKR
1.4571	316Ti	4571	318-Si/SKNb-Si 318/SKNb
1.4438 1.4439	317L 317LMN	4438 4439	317L/SNR
1.4162	S32101	LDX 2101®	2304, 2205
1.4362	S32304	SAF 2304®	2304
1.4462	S32205	2205	2205
1.4410 –	S32750 S32760	SAF 2507® –	2507/P100
1.4539	904L	904L	904L
1.4547 1.4529 1.4565 1.4652	S31254 N08926 S34565 S32654	254 SMO® 20-25-6 4565 654 SMO®	P12, P12-0^{Nb}, P54 P12, P12-0^{Nb} P16, P54 P16, P54
Dissimilar welds between stainless steels and mild steel.			307-Si
Dissimilar welds between non-molybdenum-alloyed stainless steels and mild steel.			309L-Si, 309L, 309L-HF
Dissimilar welds between molybdenum-alloyed stainless steels and mild steel.			P5
For difficult-to-weld steels (Mn-steel, tool steel, high temperature steel). Also for welding stainless steel to unalloyed steel.			P7
Inconel 600 and 9% Ni-steels. Also for welding Ni-based alloys to stainless or unalloyed steel and for surfacing.			P10
For welding steels for moderately high temperature applications.			309-Si
For welding steels for high temperature applications.			310 253 MA 353 MA

For more detailed information, see "Applications" on page 6.

SAF 2304 and SAF 2507 are produced under licence from AB Sandvik Steel.

Standard dimensions

Wire type	Diameter, mm 0.80	1.00	1.20	1.60	2.00	2.40	3.20	4.00
MIG	x	x	x	x				
TIG		x	x	x	x	x	x	
SAW						x	x	x

Quality assurance and marking

Avesta Welding solid wire is supplied with a 3.1.B certificate showing the actual chemical composition of the delivered lot. Each spool and each packet has the following marking:

- Avesta Welding brand name
- Lot number
- Weight
- Standard designation (where applicable)
- Approval (where applicable)
- Warning label

Each TIG rod is marked at both ends.

Additional information

Further information on Avesta Welding products can be found in printed matter, such as

- Avesta Welding Manual
- Data sheets
- "How to weld..." (series of brochures covering Outokumpu Stainless special grades)

and on www.avestawelding.com

Packaging data

MIG Precision layer wound on wire basket spools.

OD 300 mm
ID 51 mm
Width 100 mm
Weight 15 kg

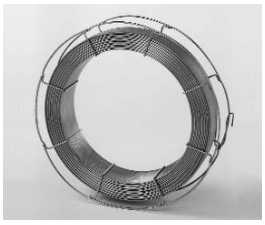
Also available in drums and on big reels.

TIG Packed in cardboard box.

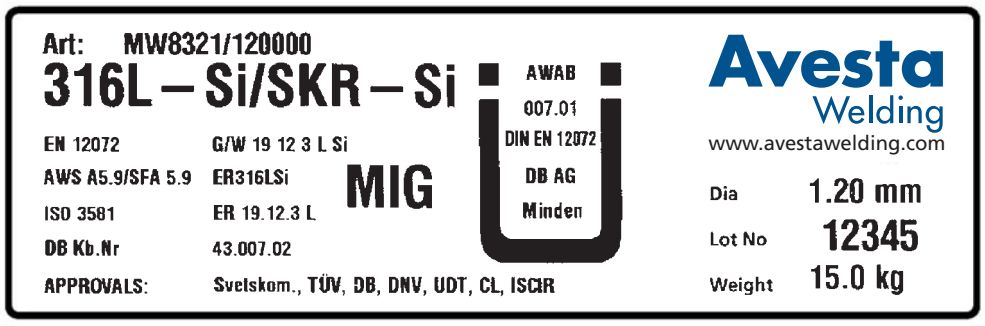
Cut length 1000 mm
Weight 5 kg

SAW Precision layer wound on wire basket spools.

ID 300 mm
Width 100 mm
Weight 25 kg



Other packaging or dimensions are also available.



Avesta Welding has been ISO 9002 approved since 1991. In 2003 the approval was upgraded to ISO 9001:2000. Certificate No. FM 20031

Applications

248 SV
For welding austenitic-ferritic-martensitic components in applications demanding high wear resistance and high strength.

308L/MVR, 308L-Si/MVR-Si
Low carbon 19/9 type wire with excellent general corrosion resistance for welding ASTM 304/304L.

308H
High carbon 19/9 type wire with enhanced creep resistance for welding ASTM 304.

347-Si/MVNb-Si, 347/MVNb
Nb-stabilised 19/9 type wire for welding Nb and Ti-stabilised steels of the ASTM 321 type. This wire offers better creep resistance than other 19/9 type wires in environments where service temperatures exceed 400°C.

316L-Si/SKR-Si, 316L/SKR
Low carbon 18/13/3 type wire alloyed with Mo for higher corrosion resistance than 308 type wires. This wire is used for welding ASTM 316/316L.

318-Si/SKNb-Si, 318/SKNb
Nb-stabilised 18/13/3 type wire for welding Nb and Ti-stabilised steels of the ASTM 316Ti type, offering a slightly better creep resistance than other 18/13/3 type wires in environments where service temperatures exceed 400°C.

317L/SNR
This wire produces a 19/14/4L weld metal with high corrosion resistance in acid and chlorine containing environments.

2304
Specially designed wire for welding SAF 2304, e.g. in nitric acid environments. Can also be used for welding Outokumpu LDX 2101.

2205
Ferritic-austenitic (duplex) wire with very high proof and tensile strength as well as excellent resistance to pitting corrosion and stress corrosion cracking. Can also be used for welding Outokumpu LDX 2101.

2507/P100
Specially designed wire for welding SAF 2507 and similar super duplex grades.

904L
Fully austenitic wire with excellent corrosion resistance in non-oxidising solutions such as sulphuric and phosphoric acids.

P12
Nickel base wire for welding nickel alloys, surfacing mild steel and welding 6Mo-steels such as Outokumpu 254 SMO. Extremely good resistance to pitting and crevice corrosion.

P12-0^{Nb}
Nickel base wire without Nb-addition, which produces a high ductility weld metal with good resistance to hot cracking. Extremely good resistance to pitting and crevice corrosion.

P16
Nickel based wire specially designed for welding 7Mo steels such as Outokumpu 654 SMO for use in extremely demanding corrosive environments.

P54
Specially designed wire for welding Outokumpu 254 SMO and Outokumpu 654 SMO exposed to highly oxidising environments.

307-Si
Fully austenitic Mn-alloyed 18/8 wire for welding dissimilar steels, such as stainless steel to carbon, low alloyed or Mn-steels.

309L-Si, 309L, 309L-HF
Highly alloyed 23/13L wire suitable for reliable, crack-resistant welds between mild steel and stainless steels of the ASTM 304/304L type. Also for surfacing, producing a 304 type deposit from the very first layer. 309L-HF has a higher ferrite content, which is advantageous when welding thick gauge material.

P5
Highly alloyed 23/13/3L wire suitable for reliable, crack-resistant welds between mild steel and stainless steels of the ASTM 316/316L type. Also for surfacing, producing a 316 type deposit from the very first layer.

P7
312 type wire producing a high strength, austenitic-ferritic weld metal with high resistance to cracking. Suitable for welding dissimilar steels, such as stainless to carbon, low-alloyed or Mn-steels. Also offering good resistance to sulphur containing gases.

P10
Nickel base wire for welding dissimilar steels, such as nickel base alloys to stainless steel or mild steel. Also suitable for welding heat resistant nickel base alloys.

309-Si
High carbon and silicon 23/13 wire for welding steels of the 309S type, for use in moderately high temperature applications.

310
Fully austenitic wire of the 26/20 type for welding steels such as ASTM 310S for use in high temperature applications.

253 MA
Specially designed wire for welding high temperature steels, such as Outokumpu 253 MA. Possesses even better high-temperature properties than ASTM 310S.

353 MA
Fully austenitic wire, specially designed for welding high temperature steels, such as Outokumpu 353 MA.

Welding recommendations, standard austenitic grades

All values are approximate and may have to be adjusted, depending on the thickness of the metal and the object being welded.

MIG welding

	Wire diam. mm	Current A	Voltage V
Short-arc	0.80 1.00	90 – 120 110 – 140	19 – 22 19 – 22
Spray-arc	0.80 1.00 1.20 1.60	150 – 170 170 – 200 200 – 270 250 – 330	24 – 27 25 – 28 26 – 29 27 – 30
Pulsed arc*	1.20	160 – 260	24 – 30

* Pulsed parameters: I_{peak} 300 – 400 A
$I_{background}$ 50 – 150 A
Frequency 80 – 120 Hz

MIG welding is normally carried out as spray or pulsed arc. Spray-arc is mostly used in the horizontal position. Welding with pulsed arc using a synergic pulsed machine can be performed with a 1.20 mm diam. wire in all positions. The pulsed arc is also advantageous when welding high alloyed stainless and nickel base fillers such as Avesta 2507/P100, 904L and P12, ensuring a controlled and stable arc with a minimum of spatter. Short-arc welding is normally only used for material thicknesses < 3.0 mm, for welding root beads and for position welding.

TIG welding

Wire diameter, mm	Current, A	Voltage, V
1.00	50 – 70	9 – 11
1.20	60 – 80	9 – 11
1.60	80 – 110	10 – 12
2.00	100 – 130	14 – 16
2.40	130 – 160	16 – 18
3.20	160 – 200	17 – 19

SA welding

Wire diameter mm	Current A	Voltage V	Travel speed cm/min
2.40	275 – 375	28 – 32	30 – 60
3.20	325 – 450	29 – 33	25 – 55
4.00	425 – 575	30 – 34	25 – 50

Submerged arc welding is normally performed using direct current, positive polarity (DC+). In cases were low dilution is required, e.g. cladding of mild steel, the electrode can be connected to the minus pole (DC–), resulting in less dilution with the base material.

Shielding gas recommendations

MIG welding

Steel type	Gas flow 12 – 16 l/min
Duplex	Ar + 2% O_2 or Ar + 30% He + 2.5% CO_2
Standard austenitic	Ar + 2% O_2 or Ar + 2 – 3% CO_2
Heat resisting	Ar or Ar + 30% He + 2.5% CO_2
Fully austenitic	Ar or Ar + 30% He + 2.5% CO_2

Effects of gas addition

- 30% He improves fluidity and arc stability and allows a higher welding speed.
- 1 – 2% O_2 or 2 – 3% CO_2 increases the arc stability.
- 1 – 2% N_2 can improve mechanical and corrosion properties when welding nickel base and super duplex alloys.
- 0.03% NO will contribute to lower ozon emissions and a somewhat more stable arc.

TIG welding

Steel type	Gas flow 5 – 12 l/min
Duplex	Ar or Ar + 2% N_2
Standard austenitic	Ar
Heat resisting	Ar
Fully austenitic	Ar or Ar + 2% N_2

Effects of gas addition

- Up to 2% N_2 ensures optimum corrosion properties (improves pitting resistance) when welding duplex, super duplex and fully austenitic steels.
- 30% He or 2 – 3% H_2 allows a high travel speed when fully automatic welding.
- TIG welding of tubes and pipes often requires a purging gas to achieve good corrosion resistance if pickling from the inside cannot be performed. The purging gas is normally pure argon or Formier gas (90% N_2 + 10% H_2), gas flow 15 – 20 l/min.

Effects of silicon content when MIG welding

MIG and TIG wires from Avesta Welding are available with either a low or a high silicon content. The high silicon content gives better arc stability and better fluidity. This also gives a more attractive weld surface and reduces the porosity as well as the spatter. The high-silicon type is only available for welding materials where unaffected resistance to hot cracking has been demonstrated in connection with welding.

The submerged-arc wire is produced only with low silicon content, since most granular fluxes give rise to silicon alloying, and high silicon levels can cause hot cracking.

Cast and helix

Cast and helix are terms used to describe two wire properties, which are very important for the MIG welding sequence.

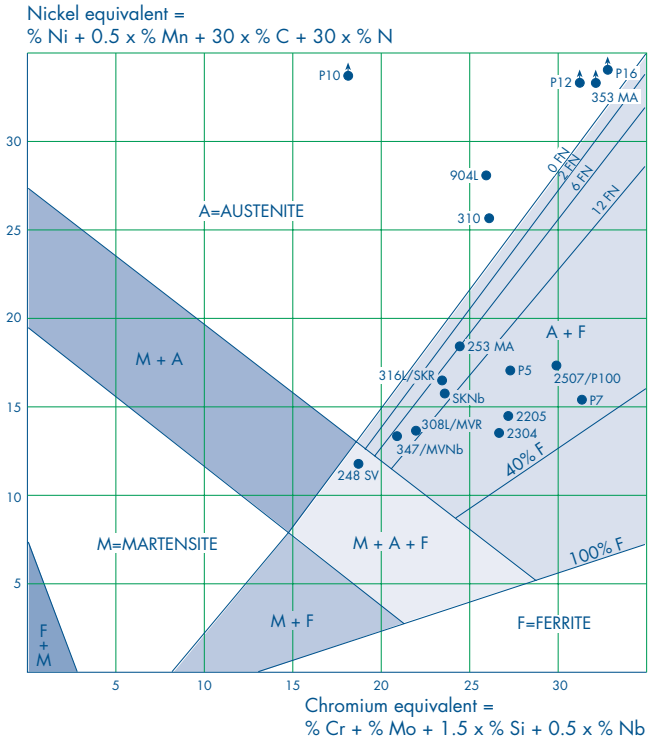
Cast is the diameter of a single loop of wire, cut from the spool and laid unrestrained on a flat surface. Too high or too low a cast can cause wire-feeding disturbance in the wire feeder as well as in the contact tip, which will have a negative effect on the arc stability.

Helix is the vertical distance between the ends of a single loop of wire, cut from the spool and laid unrestrained on a flat surface. Too large a helix will cause rotation of the wire in the feeder and contact tip.

MIG wire from Avesta Welding has a cast of 800–1300 mm and a helix of maximum 25 mm which ensures best feedability and welding properties in most applications and welding machines. These values also meet the requirements stated in AWS A5.9.

Models for ferrite prediction

The ferrite content of a weldment can be described in several different ways, for example given in per cent according to ASTM E562. This method, however, is time consuming and expensive. The ferrite value is therefore normally given measured by a magnetic method such as Magne-Gage or ferritescope or calculated in terms of the weld metal composition. Nowadays, this latter approach is often preferred, using either the Schaeffler-DeLong (see diagram) or WRC-92 diagrams. The ferrite content is given as ferrite number, FN. The relationship between percentage and FN according to Schaeffler-DeLong correlate well up to 18 FN. Above this level, values should be given according to WRC-92.



Flux recommendations

Avesta Welding offers three types of submerged arc wire welding fluxes:

Flux 801 is a neutral chromium-compensated agglomerated flux for use in combination with all types of stabilised and non-stabilised Cr-Ni and Cr-Ni-Mo steels.

Flux 805 is a basic slightly chromium-compensated agglomerated flux, primarily designed for welding with high-alloy stainless fillers such as Avesta P12, 904L and 2205. Standard Cr-Ni and Cr-Ni-Mo fillers can also be welded with excellent results.

Flux 807 is a highly basic (B.I. 2.7) agglomerated flux. It is not chromium-compensated, which results in a slightly lower ferrite content in the weld metal, compared to the consumable.

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