

For Stainless Steel

A guide for selecting welding consumables

Steel type	Key note for application	SMAW	FCAW	GMAW	GTAW	SAW
304	•General	NC-38	DW-308 DW-308LP	MGS-308	TGS-308	PFS-1 / US-308
304L	•Cryogenic temperatures	NC-38LT	DW-308LT		TGS-308L	PFS-1LT / US-308L
	•Low carbon 0.04% max.	NC-38L	DW-308L DW-308LP	MGS-308LS	TGS-308L TGX-308L	PFS-1 / US308L
304H	•High temperature service and solution treatment	NC-38, NC-38L	DW-308LH			
304N2	•High temperatures	NC-38H	DW-308H			
-	•General		DW-308N2			
	•Dissimilar-metal joints	NC-39 NC-39L NC-39MoL	DW-309 DW-309L DW-309MoL DW-309LP DW-309MoLP	MGS-309 MGS-309LS	TGS-309 TGS-309L TGX-309L	PFS-1 / US-309 PFS-1 / US-309L
	•High temperature service and solution treatment		DW-309LH			
316	•General	NC-36	DW-316 DW-316LP		TGS-316	PFS-1M / US-316 (single pass) PFS-1 / US-316 (multi-pass)
316L	•Cryogenic temperatures	NC-36LT	DW-316LT		TGS-316L	
	•Low carbon (0.04% max.)	NC-36L	DW-316L DW-316LP	MGS-316LS	TGS-316L TGX-316L	PFS-1M / US-316L (single pass) PFS-1 / US-316L (multi-pass)
	•High temperature service and solution treatment	NC-36, NC-36L	DW-316LH			
316LN	•Low carbon (0.04% max.)		DW-317L			
316H	•High temperatures		DW-316H			
-	•Urea	NC-316MF			N04051 TGS-310MF	
317L	•Low carbon (0.04% max.)	NC-317L	DW-317L		TGS-317L	PFS-1 / US-317L
347	•General	NC-37	DW-347		TGS-347 TGX-347	PFS-1 / US-347
	•Low carbon	NC-37L		MGS-347S		
	•High temperatures	NC-37	DW-347H			
321	•General	NC-37	DW-347			PFS-1 / US-347
	•High temperatures		DW-347H			
310S	•General	NC-30	DW-310		TGS-310	
312	•General	NC-32	DW-312			
-	•Duplex stainless	NC-329M	DW-329A DW-329AP		TGS-329E	
410	•General	CR-40		MGS-410	TGS-410	PFS-4M / US-410
405, 409	•Overlaying in cladding	CR-40Cb	DW-410Cb		TGS-410Cb	
	•Underlaying in cladding	CR-43Cb CR-43CbS	DW-430CbS			
-	•Low carbon martensite		MXA-135N MXA-410NM			
409, 430, 436 410L	•Car exhaust system		MXA-430M	MGS-430M		

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■ Tips for better welding results for individual welding processes

SMAW

- (1) Use proper welding currents because the use of an excessive current causes overheating electrodes and thereby welding usability and weld metal mechanical properties can be deteriorated.
- (2) Keep the arc as short as possible.
- (3) Control the weaving width of electrode within two and a half times the diameter of the electrode.

FCAW

1. Features:

- (1) DW stainless flux-cored wires are cost-effective wires because of high welding efficiency with the deposition rate 2-4 times as high as those of stick electrodes as shown in Fig. 1 and deposition efficiency of about 90%.
- (2) DW stainless wires offer a wider range of current and voltage in comparison with solid wire as shown in Fig. 2, which facilitates easier application for both semi-automatic and automatic welding.
- (3) DW stainless series has excellent usability and weldability with stable arc, low spatter, good slag removal, smooth bead appearance, and high X-ray soundness.

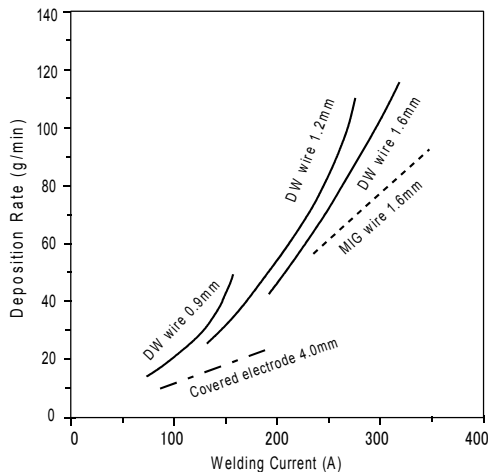


Fig. 1 Deposition rate as a function of welding current

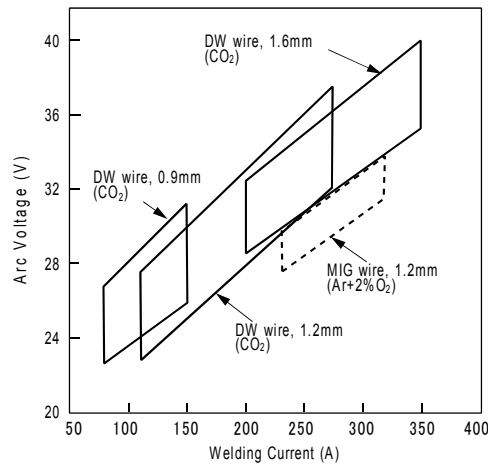


Fig. 2 Proper ranges of welding current and arc voltage

2. Notes on usage

- (1) **Welding power source:**
Use a DC power source with constant voltage and the polarity DC-EP. Inverter-type welding power sources can also be used. When the use of a certain pulsed arc power source causes much spatter, use the wire with ordinary currents, turning off the pulse switch.
- (2) **Shielding gas:**
Use CO₂ for shielding gas for general applications. Ar-CO₂ mixtures with 20-50% CO₂ can also be used, but compared with CO₂, porosity (pit and blowhole) is apt to occur. The proper flow rate of shielding gas is 20-25 liter/min.
- (3) **Wire extension:**
Keep the wire extension at about 15 mm for 0.9-mm wire and 15-20 mm for 1.2- and 1.6-mm wire. The use of a shorter wire extension may cause pit and worm-tracking porosity. The wire extension in welding with an Ar-CO₂ mixture should be 5 mm longer than in use of CO₂.
- (4) **Protection against wind:**
When wind velocity at the vicinity of an arc is more than 1 m/sec., blowhole is apt to occur, and dissolution of nitrogen into the weld metal may deteriorate slag removal and decrease the ferrite content of the weld metal, thereby causing hot cracking. To prevent these problems, use an adequate shielding gas flow rate and a windscreen.
- (5) **Welding fumes:**
Flux-cored wires generate much more welding fumes in terms of the amount of fumes at unit time in comparison with that of covered electrodes. To protect welders from harmful welding fumes, be sure to use a local ventilator and an appropriate respirator.
- (6) **Storage of wire:**
Once a DW stainless wire picked up moisture, it cannot be dried at high temperatures, unlike covered electrodes. If a DW wire was left in a wire feeder in a high-temperature high-humidity atmosphere in summer season, a wet environment in rainy season or a dewfall environment at night in winter season, the use of it may cause pit and worm-tracking porosity due to moisture pick up. Once a wire was unpacked, the wire should be kept in an area of low humidity, taking appropriate preventive measures against dewfall water and dust.

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3. Applications

(1) Butt welding:

Applicable plate thicknesses are 2 mm or larger with a 1.2mm wire and 5 mm or larger with a 1.6mm wire in flat position. P-series wires enable to weld thin plates with 3-4 mm thickness in vertical position. One-side welding can be applied for similar-shape grooves in flat, horizontal and vertical positions by using a backing material of FBB-3 (T size). In this case, the root opening should be about 3-4 mm to obtain good reverse beads.

(2) Horizontal fillet welding:

Proper welding speeds are approximately 30-70 cm/min in horizontal fillet welding. With a 309 type wire, dissimilar-metal welding of stainless steel to carbon steel can be done in the same welding condition as used for welding stainless steels. However to secure the ferrite content of weld metal, welding currents should be 200A or lower and welding speeds should be 40 cm/mm or slower with a 1.2mm wire.

(3) Overlaying and joining of clad steels:

The 1st layer of overlaying onto carbon steel should be welded with a 309 (or 309MoL) type wire by the half lapping method. In case where the dilution by the base metal is excessive, the ferrite content of the weld metal decreases and thereby hot cracking may occur. Therefore, it is important to use appropriate welding conditions to control the dilution particularly for the first layer. In order to obtain the proper dilution ratio, welding currents should be 200A or lower and welding speeds should be 20-40 cm/min with a 1.2mm wire. With a 1.6mm wire, use welding currents in the 200-250 range and welding speeds in the 20-30 cm/min range. Refer to Fig. 3.

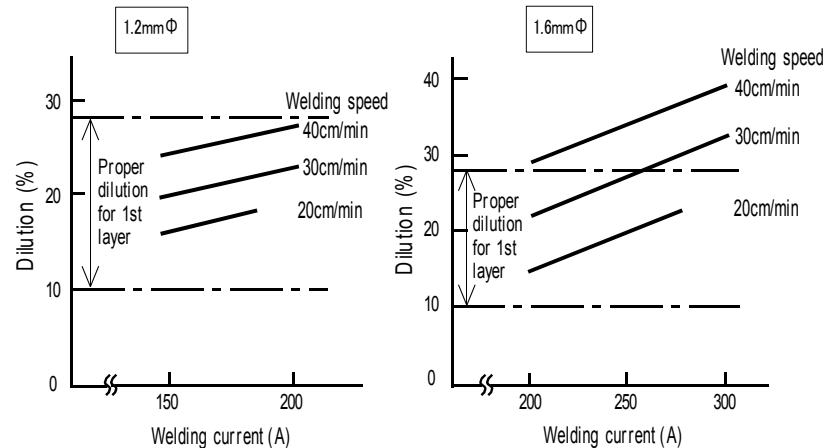


Fig. 3 Dilution ratios as a function of welding currents

GMAW

(1) Polarity:

DC-EP is suitable.

(2) Shielding gas:

98% Ar-2%O₂ mixture is recommended for general applications. Proper gas flow rates range in 20-25 l/min. Ar-CO₂ mixture is not suitable for low carbon stainless steel (Type 304L) because the carbon content of deposited metal increases.

(3) Arc length:

GMAW of stainless steel generally uses the spray arc transfer mode due to lower spatter generation. Adjust arc voltage so that arc length becomes 4-6 mm. When arc length is excessively short, blowholes are apt to occur. Inversely, when arc length is excessively long, the wetting of deposited metal on the base metal becomes poor.

(4) Protection against wind:

GMAW is likely to be influenced by wind and thereby blowholes may occur. Use a windscreen to protect the arcing area against wind when the wind velocity near the arc is 0.5m/sec or more.

(5) Pulsed arc welding:

In pulsed arc welding, a stable spray arc can be obtained even with low welding currents. Pulsed arc is suitable for overlaying, welding of thin plates and vertical welding.

GTAW

(1) Polarity:

DC-EN is suitable.

(2) Shielding gas:

Argon gas is mainly used for shielding. Suitable flow rates of shielding gas are in the range of 7-15 l/min. at 100-200A of welding current and 12-20 l/min. at 200-300A in manual GTAW.

(3) Torch:

Two types of GTAW torches are available. One has a gas lens, another has no gas lens. A torch with a gas lens provides better shielding effect preventing the weld bead from oxidation since the gas lens can provide a regular gas flow.

(4) Tungsten electrode extension:

Proper tungsten electrode extensions are generally in the range of 4-5 mm. In the case where shielding effect tends to be lower as in welding corner joint, tungsten extension is recommended to be 2-3 mm. In welding of deep groove joints, tungsten extension should be longer as 5-6 mm.

(5) Arc length:

Proper arc lengths are in the range of 1-3 mm. When it is excessively long, the shielding effect becomes poor.

(6) One-side welding without backing materials:

In the case of one-side welding without backing materials, adopt back shielding in order to prevent oxidization of the penetration bead. However, with a flux-cored filler rod for GTAW, sound penetration bead can be obtained without back shielding.

(7) Fully austenitic type filler wires:

With a fully austenitic type filler wire (e.g., TGS-310, TGS-310MF), use lower welding currents and welding speeds to prevent hot cracking.

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Ferrite content measuring methods for austenitic stainless steel weld metal

Method	Principle of measuring ferrite content
Ferrite Indicator:	Comparing the magnetic attraction between a standard ferrite percent insert and a test specimen
Ferrite Scope:	Measuring a change of magnetic induction affected by the ferrite content of a test specimen
Magne Gage:	Measuring the pull off force necessary to detach a standard permanent magnet from a test specimen
Structure Diagram:	Calculating Ni equivalent and Cr equivalent of the chemical composition of a test specimen and reading the crossing point of the two equivalents in a structure diagram. Three structure diagrams are available: Schaeffler diagram, Delong diagram and WRC diagram. See Figs. 1, 2 and 3.
Point Counting:	Calculating the area percentage of ferrite in the microstructure of a test specimen, by using a optical microscope

Fig. 1 Schaeffler Diagram

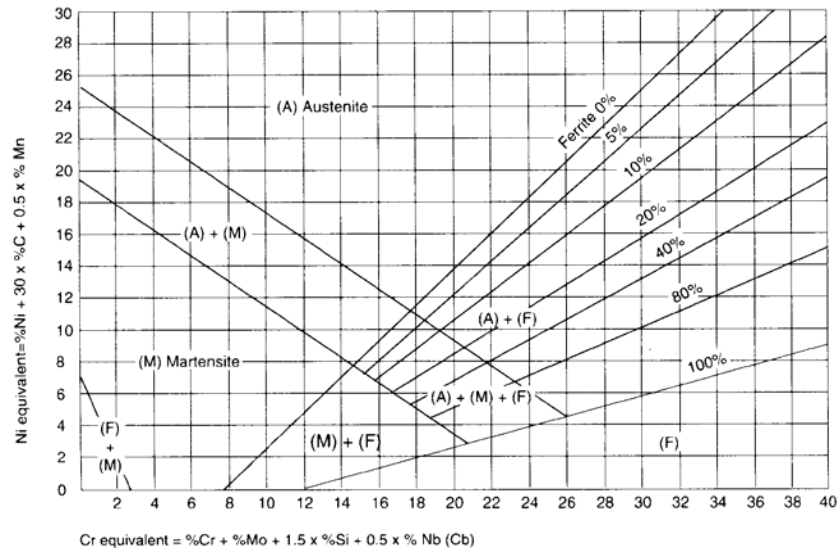


Fig. 2 Delong Diagram

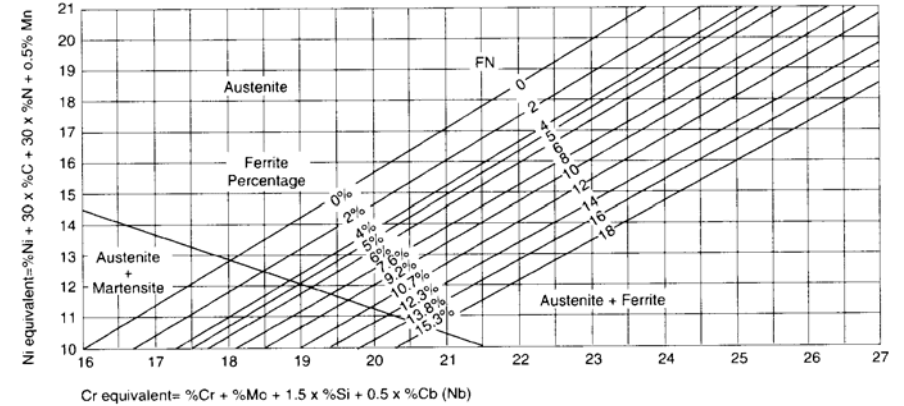


Fig. 3 WRC Diagram

