Welding highlights

- Duplex filler metals should be used. Autogenous welding is not recommended.
- Joint preparation: to achieve good and full penetration, a slightly wider root gap and joint angle than for standard stainless joints, should be used.
- The root should be gas-shielded. Suitable gases are argon, argon-nitrogen mixtures or nitrogen. Nitrogen additions improve the corrosion resistance on the root side. Careful purging is important for all stainless steels.
- Rapid cooling should be avoided, as the material structure may suffer. Avoid low heat input, e.g. when repairing. At tube to tube sheet welding, use the TIG process and Ar + 3% N_2 as the shielding gas.
- TIG is strongly recommended for root passes in one-sided welding.
- Generally, when joining duplex stainless steel to other types of material, a duplex filler metal is recommended. For welding Sandvik SAF 2507 to high alloy austenitic steels, contact Sandvik for advice.

Special observations

- Pending EN-standard, the max. service temperature is limited to 250°C for all duplex grades.
- Welding against copper-backing should be avoided because of the risk of too rapid cooling.
- Arc strike outside the joint should be avoided, as it results in very rapid cooling.
- Rotating brushes for cleaning should be avoided, because of the risk of forming micro-crevices.

SANDVIK

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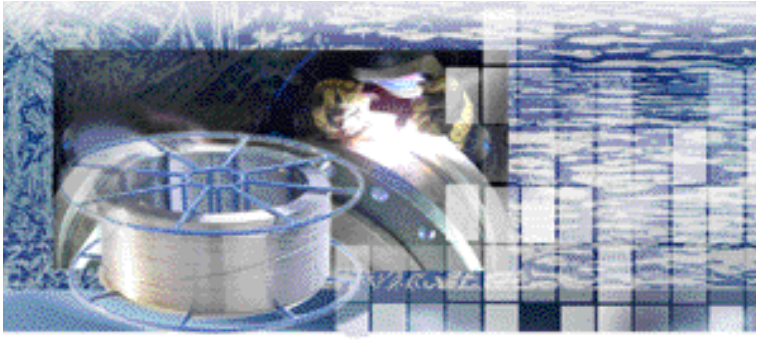
Welding guide for Sandvik duplex stainless steels



SANDVIK

Sandvik Materials Technology

● **Sandvik SAF 2304** ● **Sandvik SAF 2205** ● **Sandvik SAF 2507**

The Sandvik duplex family

Sandvik´s duplex stainless steels, containing a mixture of ferrite and austenite, give design advantages through:

- ***Excellent corrosion resistance***
- ***High strength***
- ***Good toughness***

And all Sandvik duplex grades can be **easily welded.**

Welding methods

TIG (GTAW/141) – Tungsten inert gas welding
MMA (SMAW/111) – Manual metal arc welding
MIG (GMAW/131, 135) – Metal inert gas welding
SAW (12) – Submerged arc welding

Standard stainless welding practices apply for duplex stainless steel. Any differences in welding parameters or joint design are noted in the following.

Joint preparation

Joint preparation should provide for full penetration with minimal risk of burn through.

As a rule, when welding duplex stainless steels, the root gap should be wider than for austenitic standard stainless grades. The joint angle should also be slightly wider, to ensure good penetration.

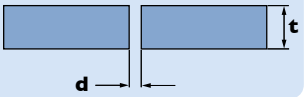
TIG is strongly recommended for root passes.

Joint preparation by plasma cutting should be followed by grinding to remove the oxide layer.

*Joint design for **one-sided** butt welding*

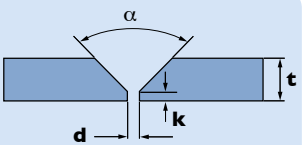
Square groove

	t mm	d mm
MMA	≤3	1–2
TIG	≤3	0–2
MIG	≤3	1–2



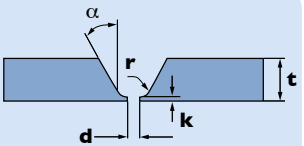
V-groove

	t mm	d mm	k mm	α
MMA	3–15	2–3	1–2	60–70°
TIG	2.5–8	2–3	1–2	60–70°
MIG	3–12	2–3	1–2	60–70°
SAW*	4–12	2–3	1–2	80–90°



U-groove

	t mm	d mm	k mm	r mm	α
MMA	>12	1–2	2–3	6	15°
TIG	>6	1–2	0–2	6–8	15°
MIG	>12	1–2	2–3	6	15°
SAW*	>10	1–2	1–3	6–8	15°

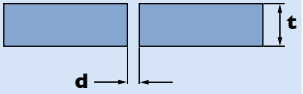


* Root pass with TIG, MIG or MMA.

Joint design for butt welding ***from both sides***

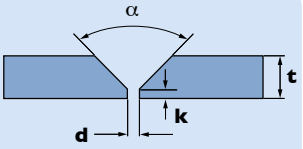
Square groove

	t mm	d mm
MMA	3–4	1.5–3
TIG	3–5	1.5–3
MIG	3–6	1.5–3



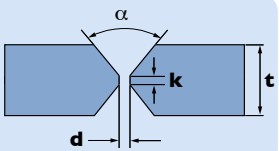
V-groove

	t mm	d mm	k mm	α
MMA	4–15	1–3	1–2	60–70°
TIG	2.5–8	1–3	1–2	60–70°
MIG	5–12	1–3	1–2	60–70°
SAW	5–12	1–3	1–2	80–90°



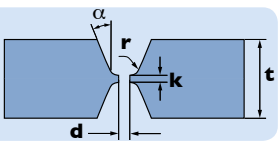
Double V-groove

	t mm	d mm	k mm	α
MMA	>10	1.5–3	1–3	60–70°
MIG	>10	1.5–3	1–3	60–70°
SAW	>10	0	3–5	90°



Double U-groove

	t mm	d mm	k mm	r mm	α
MMA	>25	1–3	1–3	6–8	10–15°
SAW	>25	0	3–5	6–8	10–15°



General welding parameters

Recommended welding parameter settings for the Sandvik duplex family are as follows:

Sandvik grade	Heat input	Interpass temperature
SAF 2304 SAF 2205	0.5–2.5 kJ/mm	No practical limitation, max. 250°C
SAF 2507	0.2–1.5 kJ/mm	Max. 150°C

The heat input should be chosen to suit the thickness of the material and the welding process.

At sufficiently high temperatures duplex parent material and weld metal will comprise 100% ferrite. During cooling from high temperatures, some ferrite will be transformed into austenite, thus providing a duplex microstructure. This austenite formation is specially important in the heat affected zone. For optimum properties, **very rapid cooling must be avoided.** Consequently, thick sections require arc energies in the upper range, while lower values should be used for thinner dimensions.

On the other hand, for any high alloy grade, very slow cooling through a critical temperature range can be detrimental. This is especially critical in the weld metal. For this reason, **the interpass temperature must not exceed 150°C for the high alloy grade Sandvik SAF 2507.**

How to calculate heat input:

$$\text{Heat input} = \frac{U \times I \times 60}{V \times 1000}$$

EXAMPLE:

TIG U = 11 V
I = 100 A
V = 60 mm/min
⇒ Heat input = 1.1 kJ/mm

U = Voltage, V. I = Current, A. V = Travel speed, mm/min

TIG welding

TIG filler metal

	Sandvik SAF 2304	Sandvik SAF 2205	Sandvik SAF 2507
Sandvik 22.8.3.L	x	x	
Sandvik 25.10.4.L		x	x

Sandvik SAF 2205: Sandvik 25.10.4.L can be used for improved corrosion resistance.

Shielding gases

Argon, argon + 1–2% nitrogen or argon-helium mixtures.

Backing gases

Backing gas is required regardless of joint design. Suitable gases are argon, argon-nitrogen mixtures, or pure nitrogen. Nitrogen additions improve the corrosion resistance on the root side.

Tack welds should also be fully protected from the root side.

Typical parameter settings

The parameter settings for welding with TIG are largely dependent upon the material thickness, type of joint, welding procedure, etc. For example, a typical root pass may use 100 amps/11 volts at a travel speed of 60 mm/min, giving a heat input of 1.1 kJ/mm.

MMA welding

Covered electrodes

	Sandvik SAF 2304	Sandvik SAF 2205	Sandvik SAF 2507
Sandvik 22.9.3.LR	x	x	
Sandvik 25.10.4.LR		x	x

Sandvik SAF 2205: Sandvik 25.10.4.LR can be used for improved corrosion resistance.

Typical parameter settings

Electrode dia.	Current, A		Voltage, V
mm	22.9.3.LR	25.10.4.LR	
2.0	35–55	–	22–28
2.5	50–75	55–85	22–28
3.25	70–120	70–110	22–28
4.0	90–160	110–150	22–28

When MMA is used for the root pass, the root side should be ground smooth after welding, or preferably gas protected, similar to TIG.

MIG welding

Wire electrode

Sandvik 22.8.3.L should be chosen as the filler metal for Sandvik SAF 2304 and Sandvik SAF 2205. Sandvik 25.10.4.L should be chosen for Sandvik SAF 2507.

Shielding gases

Spray arc: Argon + CO_2 (1–3%), Argon + 1–3% O_2
Short-arc: Argon or Ar-He-O_2 mixture.

Backing gases

Backing gas is required regardless of joint design. Suitable gases are argon, argon-nitrogen mixtures or pure nitrogen. Nitrogen additions improve the corrosion resistance on the root side.

Tack welds should also be fully protected from the root side.

Typical parameter settings

Wire dia. mm	Current A	Voltage V
Spray arc transfer		
0.8	170–200	26
1.2	180–260	29
1.6	230–350	30
Short-arc transfer		
0.8	90–120	19–21
1.2	110–140	20–22

Submerged arc welding

Wire electrode and flux

For wire electrode see "TIG welding"
The flux Sandvik 15W is recommended for all three grades.

Typical parameter settings

Wire diameter mm	Current A	Voltage V
2.4	250–450	28–32
3.2	300–500	29–34
4.0	400–600	30–35
5.0	500–700	30–35

Cleaning

Cleaning joints, before and after welding, follows standard stainless practice. Preferably use Sandvik pickling paste or, if this is not possible, fine grinding.

Avoid rotating brushes as they may cause the formation of micro-crevices and impair corrosion resistance.

Heat treatment

Preheating or post-weld heat treatment is not normally necessary or recommended.

Post-weld heat treatment in the form of solution-annealing can be used for stress relieving, or to improve the micro-structure after the use of a non-recommended welding procedure, e.g. autogenous welding.