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Dissimilar metal welds and weld joint design for duplex stainless steels

Dissimilar metal welds

Duplex stainless steels can be welded to other duplex stainless steels, to austenitic stainless steels, and to carbon and low alloy steels.

Duplex stainless steel filler metals with increased nickel content relative to the base metal are most frequently used to weld duplex stainless steels to other duplex grades. The elevated nickel content of the filler metal ensures that an adequate level of austenite is formed in the weld metal during cooling.

When welding to austenitic grades, the austenitic filler metals with low carbon and a molybdenum content intermediate between the two steels are typically used. AWS E309LMo/ER309LMo is frequently used for these joints. The same filler metal or AWS E309L/ER309L is commonly used to join duplex stainless steels to carbon and low alloy steels. If nickel-base filler metals are used, they should be free of niobium (columbium). Because austenitic stainless steels have lower strength than duplex grades, welded joints made with austenitic filler metals will not be as strong as the duplex base metal.

Table 1 summarizes filler metals frequently used to weld duplex stainless steels to dissimilar metals. These examples show the AWS electrode designation (E), but depending on the process, joint geometry and other considerations, bare wire (AWS designation ER), and flux cored wire may be considered.

Weld joint design

For duplex stainless steels, a weld joint design must facilitate full penetration and avoid undiluted base metal in the solidifying weld metal. It is best to machine rather than grind the weld edge preparation to provide uniformity to the land thickness or gap. When grinding must be done, special attention should be given to uniformity of the weld preparation and the fit-up. Any grinding burr should be removed to maintain complete fusion and penetration. For an austenitic stainless steel, a skilled welder can overcome some deficiencies in joint preparation by manipulation of the torch. For a duplex stainless steel, some of these techniques may cause a longer than expected exposure in the harmful temperature range, leading to results outside of those of the qualified procedure.

Some joint designs used with duplex stainless steels are illustrated in **Table 2.** Other designs are possible provided they assure full penetration welds and minimize the risk of burn-through.

Table 1: Welding consumables used for dissimilar welding

	Lean duplex	Standard duplex	25 Cr duplex Superduplex
Lean duplex	E2309 E2209 E309L	E2209	E2209
Standard duplex	E2209	E2209	E2594
25 Cr duplex Superduplex	E2209	E2594	E2594
304	E309L E309LMo E2209	E309LMo E2209	E309LMo E2209
316	E309LMo E2209	E309LMo E2209	E309LMo E2209
Carbon steel Low alloy steel	E309L E309LMo E2209	E309L E309LMo E2209	E309L E309LMo E2209

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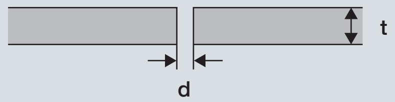
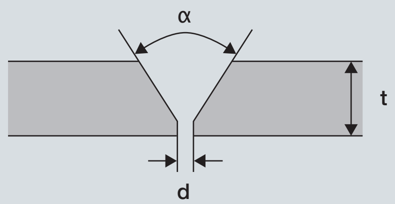
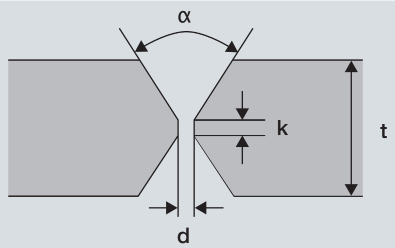
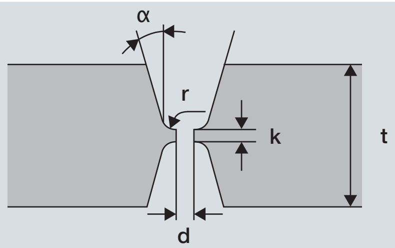
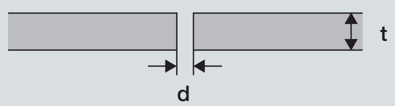
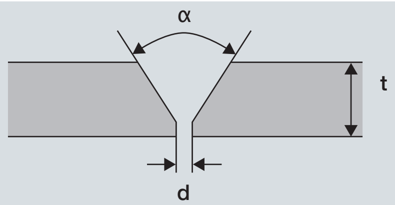
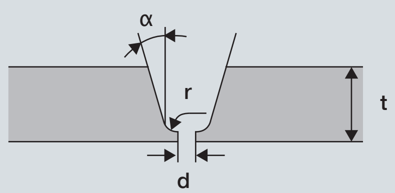
Table 2: Examples of weld joint designs used with duplex stainless steels

Groove	Process	Thickness t (mm)	Gap d (mm)	Root k (mm)	Bevel α (°)
	GTAW	3–5	1–3	–	–
	GMAW	3–6	1–3	–	–
	SMAW	3–4	1–3	–	–
	SMAW	4–15	1–3	1–2	55–65
	GTAW	3–8	1–3	1–2	60–70
	GMAW	5–12	1–3	1–2	60–70
	SAW	9–12	0	5	80
	SMAW	>10	1.5–3	1–3	55–65
	GMAW	>10	1.5–3	1–3	60–70
	SAW	>10	0	3–5	90
	SMAW	> 25	1–3	1–3	10–15
	GMAW	> 25	1–3	1–3	10–15
	SAW	> 25	0	3–5	10–15
	GTAW	> 3	0–2	–	–
	GMAW	> 3	0–2	–	–
	SMAW	> 3	0–2	–	–
	SMAW	3–15	2–3	1–2	60–70
	GTAW	2.5–8	2–3	1–2	60–70
	GMAW	3–12	2–3	1–2	60–70
	SAW	4–12	2–3	1–2	70–80
	SMAW	12–60	1–2	2–3	10–15
	GTAW	> 8	1–2	1–2	10–15
	GMAW	>12	1–2	2–3	10–15
	SAW	>10	1–2	1–3	10–15

Source: ArcelorMittal