WELDING PROCEDURE SPECIFICATION (WPS)

Sondad Industries	Lincoln NR-232	0	10-01-22
Company Name	WPS No.	Rev. No.	Date
Joe Gartrell	Prequalified	-	
Authorized by	Supporting PQR(s)	CVN Report	
10-01-22			
Date			

BASE METALS	Specification	Type or Grade	AWS Group No.
Base Material	Any Listed AWS	D1.1-2020	I or II
Welded To	Any Listed AWS	D1.1-2020	I, II or III
Backing Material	Any Listed AWS	D1.1-2020	I,II
Other			

BASE METAL THICKNESS	As-Welded	With PWHT
CJP Groove Welds	See following images	-
CJP Groove w/CVN	-	-
PJP Groove Welds	See following images	-
Fillet Welds	See following images	-
DIAMETER		

JOINT DETAILS	
Groove Type	See following images
Groove Angle	See following images
Root Opening	See following images
Root Face	See following images
Backgouging	As needed
Method	CAC - Grinder

POSTWELD HEAT TREATMENT	
Temperature	-
Time at Temperature	-
Other	-

JOINT DETAILS (Sketch)

*1 - Lincoln Electric NR-232
*2 - See following pages

For welding in accordance with AWS D1.8 or AISC 341no combination of amps, volts and travel speed can exceed the qualified heat input by the filler metal manufacture. See following pages

PROCEDURE								
Weld Layer(s)	1-n	1-n	1-n	1-n	1-n	1-n	1-n	-
Weld Pass(es)	1-n	1-n	1-n	1-n	1-n	1-n	1-n	-
Process	FCAW	FCAW	FCAW	FCAW	FCAW	FCAW	FCAW	-
Type *(Semiautomatic, Mechanized, etc.)*	Semiautomatic	Semiautomatic	Semiautomatic	Semiautomatic	Semiautomatic	Semiautomatic	Semiautomatic	-
Position	All	All	All	All	All	All	All	-
Vertical Progression	Up	Up	Up	Up	Up	Up	Up	-
Filler Metal (AWS Spec.)	A5.20	A5.20	A5.20	A5.20	A5.20	A5.20	A5.20	-
AWS Classification	E71T-8	E71T-8	E71T-8	E71T-8	E71T-8	E71T-8	E71T-8	-
Diameter	0.068"	0.068"	0.068"	0.068"	0.068"	0.068"	0.068"	-
Manufacturer/Trade Name	*1	*1	*1	*1	*1	*1	*1	-
Shielding Gas (Composition)	-	-	-	-	-	-	-	-
Flow Rate	-	-	-	-	-	-	-	-
Nozzle Size	-	-	-	-	-	-	-	-
Preheat Temperature	*2	*2	*2	*2	*2	*2	*2	-
Interpass Temperature	550°F	550°F	550°F	550°F	550°F	550°F	550°F	-
Electrical Characteristics	—	—	—	—	—	—	—	—
Current Type & Polarity	DCEN	DCEN	DCEN	DCEN	DCEN	DCEN	DCEN	-
Transfer Mode	-	-	-	-	-	-	-	-
Power Source Type (*cc, cv, etc.*)	CV	CV	CV	CV	CV	CV	CV	-
Amps +/-10%	195	225	250	270	300	350	400	-
Volts +/-15%	18-19	19-21	19-21	20-22	23-24	23-24	25-27	-
Wire Feed Speed +/-10%	110	130	150	170	195	250	320	-
Travel Speed ipm +/-25%	3.0-6.8	3.8-8.3	4.3-9.2	4.8-10.5	5.9-13.4	6.8-15.6	8.8-19.4	-
Maximum Heat Input	30.8-73.2	30.8-73.2	30.8-73.2	30.8-73.2	30.8-73.2	30.8-73.2	30.8-73.2	-
Technique	—	—	—	—	—	—	—	—
Stringer or Weave	Both	Both	Both	Both	Both	Both	Both	-
Multi or Single Pass (per side)	Both	Both	Both	Both	Both	Both	Both	-
Oscillation (*Mechanized/Automatic*)	-	-	-	-	-	-	-	-
Traverse Length	-	-	-	-	-	-	-	-
Traverse Speed	-	-	-	-	-	-	-	-
Dwell Time	-	-	-	-	-	-	-	-
Number of Electrodes	-	-	-	-	-	-	-	-
Contact Tube to Work Distance	3/4"-1-1/4"	3/4"-1-1/4"	3/4"-1-1/4"	3/4"-1-1/4"	3/4"-1-1/4"	3/4"-1-1/4"	3/4"-1-1/4"	-
Peening	No	No	No	No	No	No	No	-
Interpass Cleaning	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	As Needed	-
Other								

Legend for Figures 5.1 and 5.2

Symbols for joint types

B — butt joint
C — corner joint
T — T-joint
BC — butt or corner joint
TC — T- or corner joint
BTC — butt, T-, or corner joint

Symbols for base metal thickness and penetration

P — PJP
L — limited thickness–CJP
U — unlimited thickness–CJP

Symbol for weld types

1 — square-groove
2 — single-V-groove
3 — double-V-groove
4 — single-bevel-groove
5 — double-bevel-groove
6 — single-U-groove
7 — double-U-groove
8 — single-J-groove
9 — double-J-groove
10 — flare-bevel-groove
11 — flare-V-groove

Symbols for welding processes if not SMAW

S — SAW
G — GMAW
F — FCAW

Welding processes

SMAW — shielded metal arc welding
GMAW — gas metal arc welding
FCAW — flux cored metal arc welding
SAW — submerged arc welding

Welding positions

F — flat
H — horizontal
V — vertical
OH — overhead

Dimensions

R = Root Opening
α, β = Groove Angles
f = Root Face
r = J- or U-groove Radius
D, D_1, D_2 = PJP Groove Weld Depth of Groove
S, S_1, S_2 = PJP Groove Weld Sizes corresponding to S, S_1, S_2, respectively

Joint Designation

The lower case letters, e.g., a, b, c, etc., are used to differentiate between joints that would otherwise have the same joint designation.

Notes for Figures 5.1 and 5.2

[a] Not prequalified for GMAW-S nor GTAW.

[b] Joint shall be welded from one side only.

[c] Cyclic load application places restrictions on the use of this detail for butt joints in the flat position (see 4.18.2).

[d] Backgouge root to sound metal before welding second side.

[e] SMAW detailed joints may be used for prequalified GMAW (except GMAW-S) and FCAW.

[f] Minimum weld size (S) as shown in Table 5.5. Depth of groove weld (D) as specified on drawings.

[g] If fillet welds are used in statically loaded structures to reinforce groove welds in corner and T-joints, these shall be equal to $T_1/4$, but need not exceed 3/8 in [10 mm]. Groove welds in corner and T-joints of cyclically loaded structures shall be reinforced with fillet welds

[h] Double-groove welds may have grooves of unequal depth, but the depth of the shallower groove shall be no less than one-fourth of the thickness of the thinner part joined.

[i] Double-groove welds may have grooves of unequal depth, provided these conform to the limitations of Note f. Also the weld size (E) applies individually to each groove.

[j] The orientation of the two members in the joints may vary from 135° to 180° for butt joints, or 45° to 135° for corner joints, or 45° to 90° for T-joints.

[k] For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained to support the welding operations without excessive edge melting.

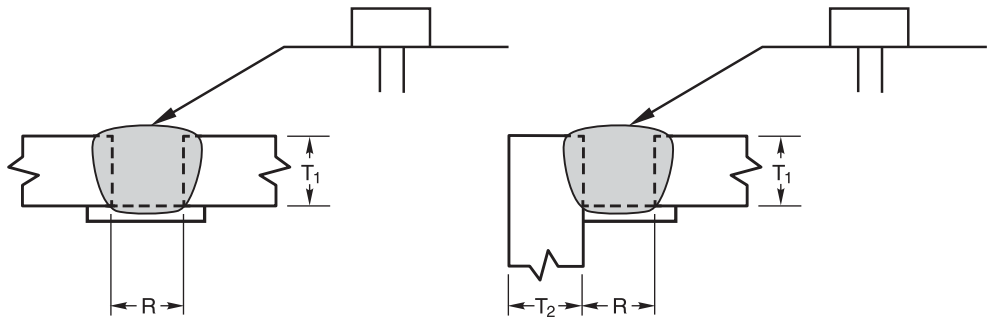
[L] Weld size (E) shall be based on joints welded flush.

[m] For flare-V-groove welds and flare-bevel-groove welds to rectangular tubular sections, r shall be as two times the wall thickness.

[n] For flare-V-groove welds to surfaces with different radii r, the smaller r shall be used.

[O] For corner and T-joints the member orientation may vary from 90° to less than or equal to 170° provided the groove angle and root opening are maintained, and the angle between the groove faces and the steel backing is at least 90°. See Figure 5.5

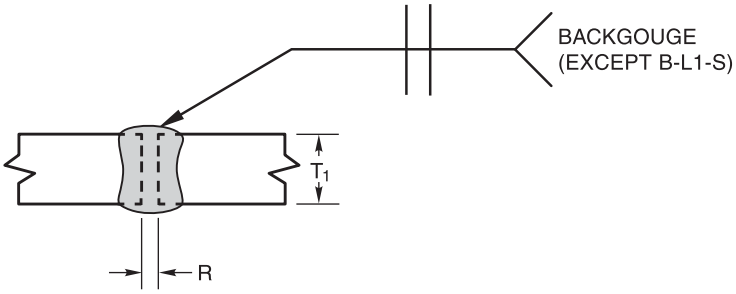
Square-groove weld (1)
Butt joint (B)
Corner joint (C)



B-L1a **C-L1a**

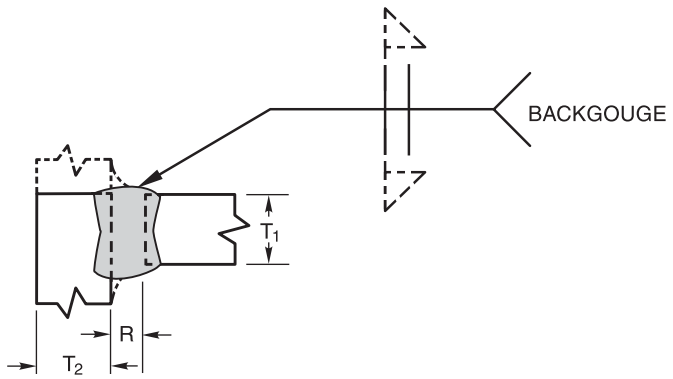
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
					Tolerances				
		T_1	T_2	Root Opening	As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	B-L1a	1/4 max.	—	$R = T_1$	+1/16, –0	+1/4, –1/16	All	—	e, j
	C-L1a	1/4 max.	U	$R = T_1$	+1/16, –0	+1/4, –1/16	All	—	e, j
FCAW GMAW	B-L1a-GF	3/8 max.	—	$R = T_1$	+1/16, –0	+1/4, –1/16	All	Not required	a, j

Square-groove weld (1)
Butt joint (B)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
					Tolerances				
		T_1	T_2	Root Opening	As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	B-L1b	1/4 max.	—	$R = \frac{T_1}{2}$	+1/16, –0	+1/16, –1/8	All	—	d, e, j
GMAW FCAW	B-L1b-GF	3/8 max.	—	R = 0 to 1/8	+1/16, –0	+1/16, –1/8	All	Not required	a, d, j
SAW	B-L1-S	3/8 max.	—	R = 0	±0	+1/16, –0	F	—	j
SAW	B-L1a-S	5/8 max.	—	R = 0	±0	+1/16, –0	F	—	d, j

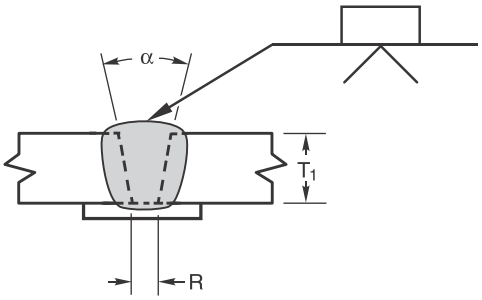
Square-groove weld (1)
T-joint (T)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
					Tolerances				
		T_1	T_2	Root Opening	As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	TC-L1b	1/4 max.	U	$R = \frac{T_1}{2}$	+1/16, –0	+1/16, –1/8	All	—	d, e, g
GMAW FCAW	TC-L1-GF	3/8 max.	U	R = 0 to 1/8	+1/16, –0	+1/16, –1/8	All	Not required	a, d, g
SAW	TC-L1-S	3/8 max.	U	R = 0	±0	+1/16, –0	F	—	d, g

Single-V-groove weld (2)
Butt joint (B)

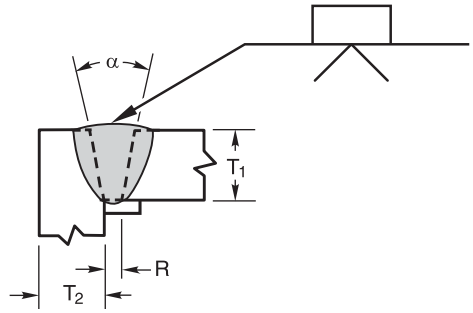
Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation		Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	B-U2a	U	—	R = 1/4	α = 45°	All	—	e, j
				R = 3/8	α = 30°	F, V, OH	—	e, j
				R = 1/2	α = 20°	F, V, OH	—	e, j
GMAW FCAW	B-U2a-GF	U	—	R = 3/16	α = 30°	F, V, OH	Required	a, j
				R = 3/8	α = 30°	F, V, OH	Not req.	a, j
				R = 1/4	α = 45°	F, V, OH	Not req.	a, j
SAW	B-L2a-S	2 max.	—	R = 1/4	α = 30°	F	—	j
SAW	B-U2-S	U	—	R = 5/8	α = 20°	F	—	j

See Notes on Page 65

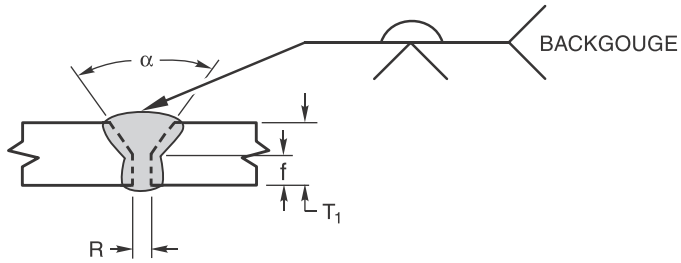
Single-V-groove weld (2)
Corner joint (C)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°

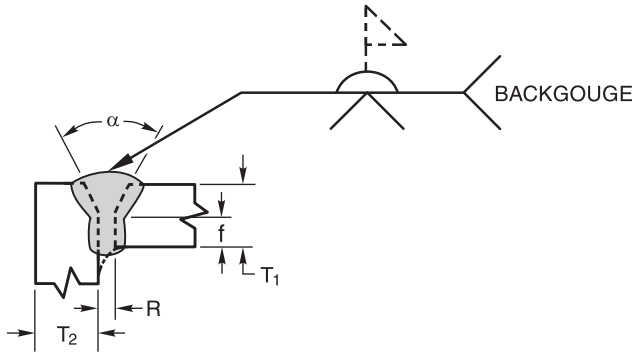
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation		Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	C-U2a	U	U	R = 1/4	α = 45°	All	—	e, o
				R = 3/8	α = 30°	F, V, OH	—	e, o
				R = 1/2	α = 20°	F, V, OH	—	e, o
GMAW FCAW	C-U2a-GF	U	U	R = 3/16	α = 30°	F, V, OH	Required	a
				R = 3/8	α = 30°	F, V, OH	Not req.	a, o
				R = 1/4	α = 45°	F, V, OH	Not req.	a, o
SAW	C-L2a-S	2 max.	U	R = 1/4	α = 30°	F	—	o
SAW	C-U2-S	U	U	R = 5/8	α = 20°	F	—	o

Single-V-groove weld (2)
Butt joint (B)



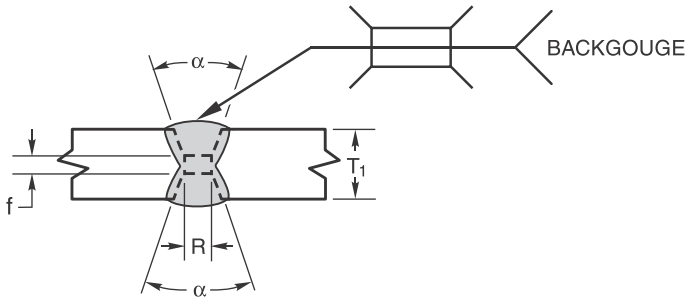
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	B-U2	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	—	d, e, j
GMAW FCAW	B-U2-GF	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	Not required	a, d, j
SAW	B-L2c-S	Over 1/2 to 1	—	R = 0 f = 1/4 max. α = 60°	R = ±0 f = +0, –f α = +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	—	d, j
		Over 1 to 1-1/2	—	R = 0 f = 1/2 max. α = 60°					
		Over 1-1/2 to 2	—	R = 0 f = 5/8 max. α = 60°					

Single-V-groove weld (2)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	C-U2	U	U	R = 0 to 1/8 f = 0 to 1/8 α = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	—	d, e, g, j
GMAW FCAW	C-U2-GF	U	U	R = 0 to 1/8 f = 0 to 1/8 α = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	Not required	a, d, g, j
SAW	C-U2b-S	U	U	R = 0 to 1/8 f = 1/4 max. α = 60°	±0 +0, –1/4 +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	—	d, g, j

Double-V-groove weld (3)
Butt joint (B)

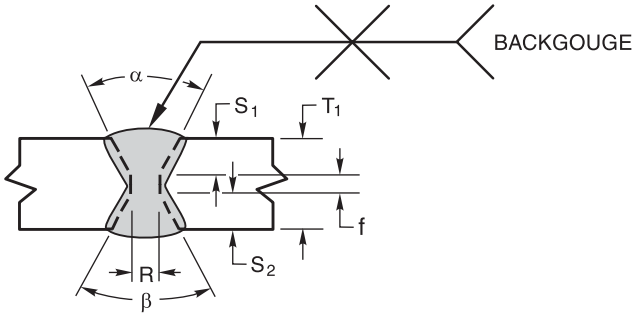


		Tolerances	
		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
		R = ±0	+1/4, –0
		f = ±0	+1/16, –0
		α = +10°, –0°	+10°, –5°
Spacer	SAW	±0	+1/16, –0
	SMAW	±0	+1/8, –0

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Root Face	Groove Angle			
SMAW	B-U3a	U Spacer = 1/8 × R	—	R = 1/4	f = 0 to 1/8	α = 45°	All	—	d, e, h, j
				R = 3/8	f = 0 to 1/8	α = 30°	F, V, OH	—	
				R = 1/2	f = 0 to 1/8	α = 20°	F, V, OH	—	
SAW	B-U3a-S	U Spacer = 1/4 × R	—	R = 5/8	f = 0 to 1/4	α = 20°	F	—	d, h, j

See Notes on Page 65

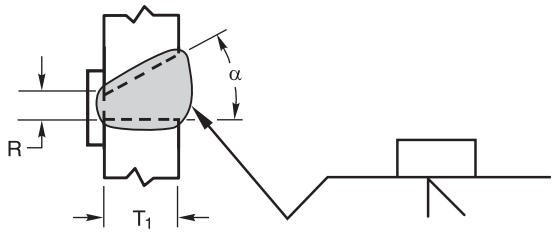
Double-V-groove weld (3)
Butt joint (B)



For B-U3c-S only		
T_1		S_1
Over	to	
2	2-1/2	1-3/8
2-1/2	3	1-3/4
3	3-5/8	2-1/8
3-5/8	4	2-3/8
4	4-3/4	2-3/4
4-3/4	5-1/2	3-1/4
5-1/2	6-1/4	3-3/4
For T_1 > 6-1/4 or $T_1 \leq 2$ $S_1 = 2/3\ (T_1 - 1/4)$		

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	B-U3b	U	—	R = 0 to 1/8 f = 0 to 1/8 α = β = 60°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	—	d, e, h, j
GMAW FCAW	B-U3-GF						All	Not required	a, d, h, j
SAW	B-U3c-S	U	—	R = 0 f = 1/4 min. α = β = 60°	+1/16, –0 +1/4, –0 +10°, –0°	+1/16, –0 +1/4, –0 +10°, –5°	F	—	d, h, j
				To find S_1 see table above: $S_2 = T_1 - (S_1 + f)$					

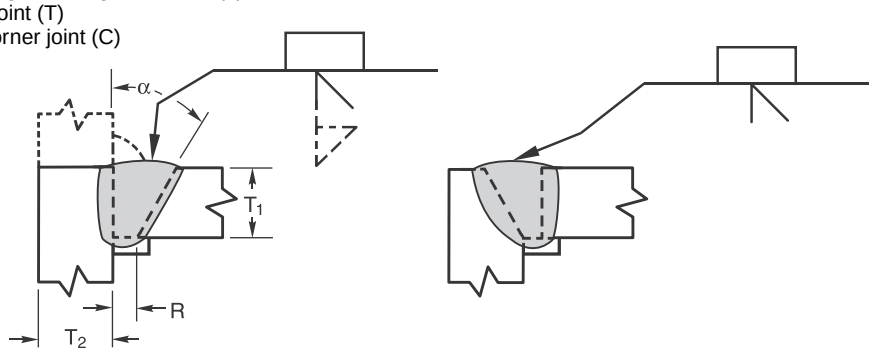
Single-bevel-groove weld (4)
Butt joint (B)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation		Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	B-U4a	U	—	R = 1/4	α = 45°	All	—	c, e, j
				R = 3/8	α = 30°	All	—	c, e, j
GMAW FCAW	B-U4a-GF	U	—	R = 3/16	α = 30°	All	Required	a, c, j
				R = 1/4	α = 45°	All	Not req.	a, c, j
				R = 3/8	α = 30°	F, H	Not req.	a, c, j
SAW	B-U4a-S	U	—	R = 3/8	α = 30°	F	—	c, j
				R = 1/4	α = 45°			

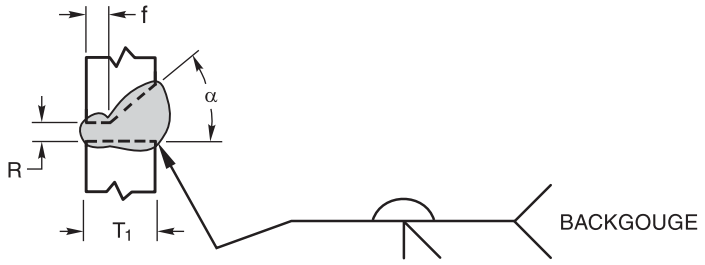
Single-bevel-groove weld (4)
T-joint (T)
Corner joint (C)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/4, –1/16
α = +10°, –0°	+10°, –5°

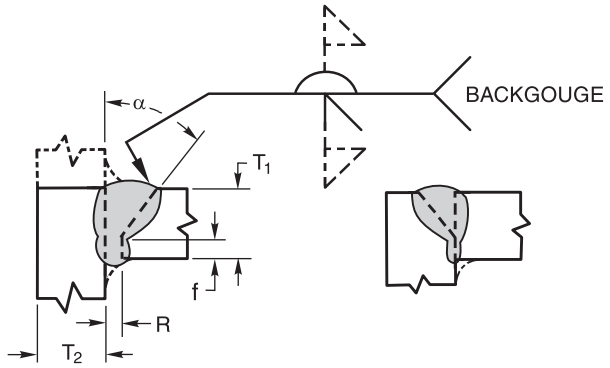
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation		Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle			
SMAW	TC-U4a	U	U	R = 1/4	α = 45°	All	—	e, g, k, o
				R = 3/8	α = 30°	F, V, OH	—	e, g, k, o
GMAW FCAW	TC-U4a-GF	U	U	R = 3/16	α = 30°	All	Required	a, g, k, o
				R = 3/8	α = 30°	F	Not req.	a, g, k, o
				R = 1/4	α = 45°	All	Not req.	a, g, k, o
SAW	TC-U4a-S	U	U	R = 3/8	α = 30°	F	—	g, k, o
				R = 1/4	α = 45°			

Single-bevel-groove weld (4)
Butt joint (B)



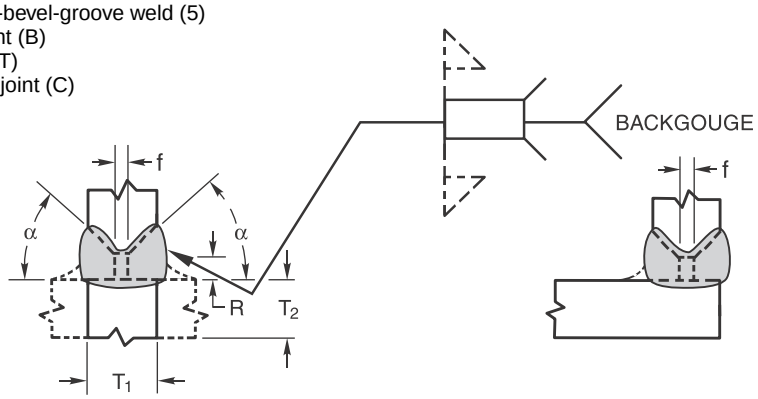
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	B-U4b	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 45°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited 10°, –5°	All	—	c, d, e, j
GMAW FCAW	B-U4b-GF	U	—				All	Not required	a, c, d, j
SAW	B-U4b-S	U	—	R = 0 f = 1/4 max. α = 60°	±0 +0, –1/8 +10°, –0°	+1/4, –0 ±1/16 10°, –5°	F	—	c, d, j

Single-bevel-groove weld (4)
T-joint (T)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	TC-U4b	U	U	R = 0 to 1/8 f = 0 to 1/8 α = 45°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited 10°, –5°	All	—	d, e, g, j, k
GMAW FCAW	TC-U4b-GF	U	U				All	Not required	a, d, g, j, k
SAW	TC-U4b-S	U	U	R = 0 f = 1/4 max. α = 60°	±0 +0, –1/8 +10°, –0°	+1/4, –0 ±1/16 10°, –5°	F	—	d, g, j, k

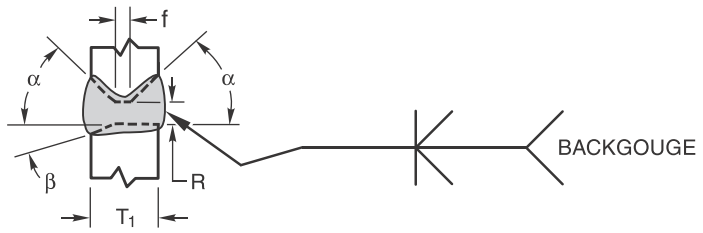
Double-bevel-groove weld (5)
Butt joint (B)
T-joint (T)
Corner joint (C)



	Tolerances	
	As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
	R = ±0	+1/4, –0
	f = +1/16, –0	±1/16
	α = +10°, –0°	+10°, –5°
Spacer	+1/16, –0	+1/8, –0

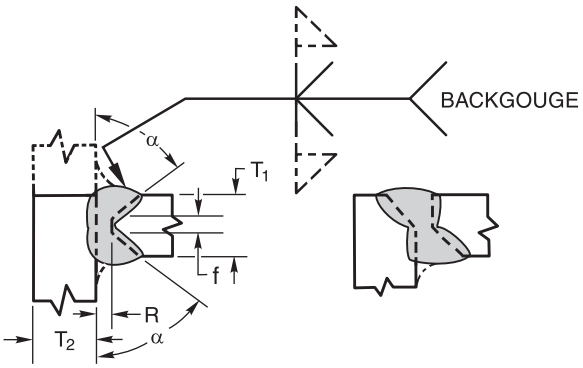
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Root Face	Groove Angle			
SMAW	B-U5b	U Spacer = 1/8 × R	—	R = 1/4	f = 0 to 1/8	α = 45°	All	—	c, d, e, h, j
	TC-U5a	U Spacer = 1/4 × R	U	R = 1/4	f = 0 to 1/8	α = 45°	All	—	d, e, g, h, j, k
				R = 3/8	f = 0 to 1/8	α = 30°	F, OH	—	d, e, g, h, j, k

Double-bevel-groove weld (5)
Butt joint (B)



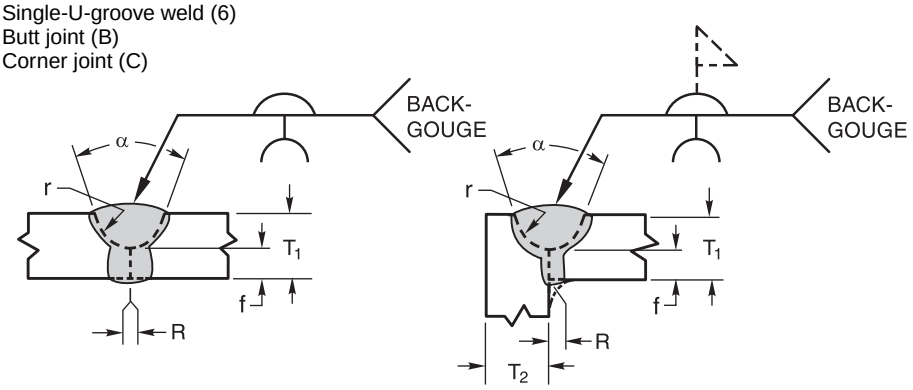
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	B-U5a	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 45° β = 0° to 15°	+1/16, –0 +1/16, –0 α+β=+10°,–0°	+1/16, –1/8 Not limited α+β=+10°–5°	All	—	c, d, e, h, j
GMAW FCAW	B-U5-GF	U	—	R = 0 to 1/8 f = 0 to 1/8 α = 45° β = 0° to 15°	+1/16, –0 +1/16, –0 α+β=+10°,–0°	+1/16, –1/8 Not limited α+β=+10°–5°	All	Not required	a, c, d, h, j

Double-bevel-groove weld (5)
T-joint (T)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Gas Shielding for FCAW	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8			
SMAW	TC-U5b	U	U	R = 0 to 1/8 f = 0 to 1/8 α = 45°	+1/16, –0 +1/16, –0 +10°, –0°	+1/16, –1/8 Not limited +10°, –5°	All	—	d, e, g, h, j, k
GMAW FCAW	TC-U5-GF	U	U				All	Not required	a, d, g, h, j, k
SAW	TC-U5-S	U	U	R = 0 f = 1/4 max. α = 60°	±0 +0, –3/16 +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	—	d, g, h, j, k

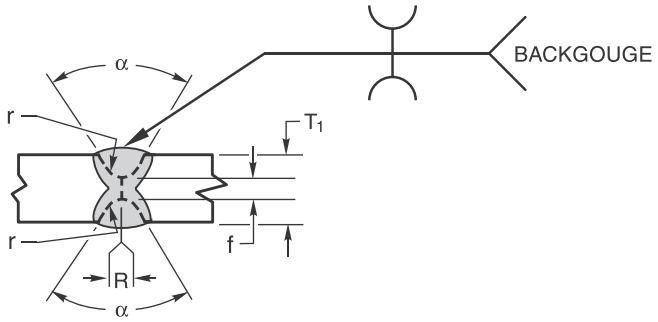
Single-U-groove weld (6)
Butt joint (B)
Corner joint (C)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/16, –1/8
α = +10°, –0°	+10°, –5°
f = ±1/16	Not Limited
r = +1/8, –0	+1/8, –0

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	B-U6	U	—	R = 0 to 1/8	α = 45°	f = 1/8	r = 1/4	All	—	d, e, j
				R = 0 to 1/8	α = 20°	f = 1/8	r = 1/4	F, OH	—	d, e, j
	C-U6	U	U	R = 0 to 1/8	α = 45°	f = 1/8	r = 1/4	All	—	d, e, g, j
				R = 0 to 1/8	α = 20°	f = 1/8	r = 1/4	F, OH	—	d, e, g, j
GMAW FCAW	B-U6-GF	U	—	R = 0 to 1/8	α = 20°	f = 1/8	r = 1/4	All	Not req.	a, d, j
	C-U6-GF	U	U	R = 0 to 1/8	α = 20°	f = 1/8	r = 1/4	All	Not req.	a, d, g, j

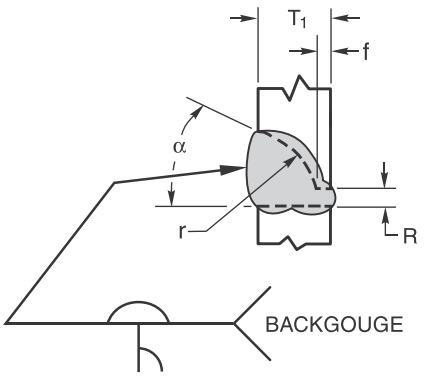
Double-U-groove weld (7)
Butt joint (B)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
For B-U7 and B-U7-GF	
R = +1/16, –0	+1/16, –1/8
α = +10°, –0°	+10°, –5°
f = +1/16, –0	Not Limited
r = +1/4, –0	±1/16
For B-U7-S	
R = +0	+1/16, –0
α = +10°, –0°	+10°, –5°
f = +0, –1/4	±1/16
r = +1/4, –0	±1/16

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	B-U7	U	—	R = 0 to 1/8	α = 45°	f = 1/8	r = 1/4	All	—	d, e, h, j
				R = 0 to 1/8	α = 20°	f = 1/8	r = 1/4	F, OH	—	d, e, h, j
GMAW FCAW	B-U7-GF	U	—	R = 0 to 1/8	α = 20°	f = 1/8	r = 1/4	All	Not required	a, d, j, h
SAW	B-U7-S	U	—	R = 0	α = 20°	f = 1/4 max.	r = 1/4	F	—	d, h, j

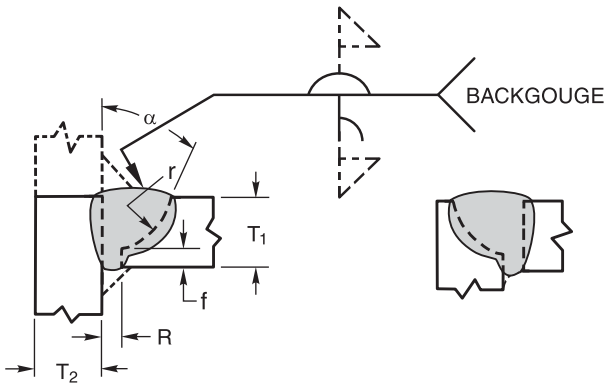
Single-J-groove weld (8)
Butt joint (B)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
B-U8 and B-U8-GF	
R = +1/16, –0	+1/16, –1/8
α = +10°, –0°	+10°, –5°
f = +1/8, –0	Not Limited
r = +1/4, –0	±1/16
B-U8-S	
R = ±0	+1/4, –0
α = +10°, –0°	+10°, –5°
f = +0, –1/8	±1/16
r = +1/4, –0	±1/16

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	B-U8	U	—	R = 0 to 1/8	α = 45°	f = 1/8	r = 3/8	All	—	c, d, e, j
GMAW FCAW	B-U8-GF	U	—	R = 0 to 1/8	α = 30°	f = 1/8	r = 3/8	All	Not req.	a, c, d, j
SAW	B-U8-S	U	—	R = 0	α = 45°	f = 1/4 max.	r = 3/8	F	—	c, d, j

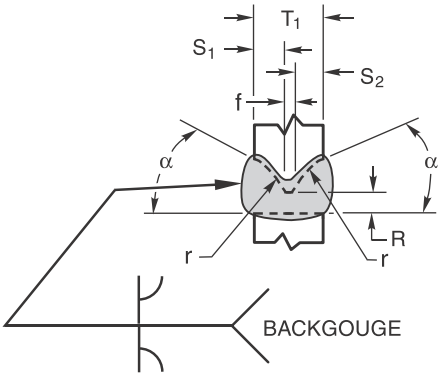
Single-J-groove weld (8)
T-joint (T)
Corner joint (C)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
TC-U8a and TC-U8a-GF	
R = +1/16, –0	+1/16, –1/8
α = +10°, –0°	+10°, –5°
f = +1/16, –0	Not Limited
r = +1/4, –0	±1/16
TC-U8a-S	
R = ±0	+1/4, –0
α = +10°, –0°	+10°, –5°
f = +0, –1/8	±1/16
r = +1/4, –0	±1/16

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	TC-U8a	U	U	R = 0 to 1/8	α = 45°	f = 1/8	r = 3/8	All	—	d, e, g, j, k
				R = 0 to 1/8	α = 30°	f = 1/8	r = 3/8	F, OH	—	d, e, g, j, k
GMAW FCAW	TC-U8a-GF	U	U	R = 0 to 1/8	α = 30°	f = 1/8	r = 3/8	All	Not required	a, d, g, j, k
SAW	TC-U8a-S	U	U	R = 0	α = 45°	f = 1/4 max.	r = 3/8	F	—	d, g, j, k

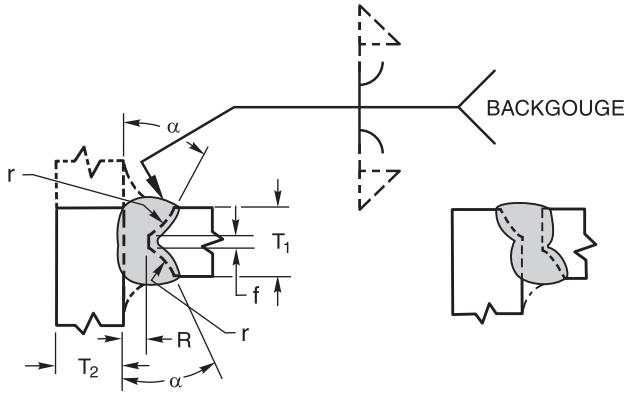
Double-J-groove weld (9)
Butt joint (B)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/16, –1/8
α = +10°, –0°	+10°, –5°
f = +1/16, –0	Not Limited
r = +1/8, –0	±1/16

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	B-U9	U	—	R = 0 to 1/8	α = 45°	f = 1/8	r = 3/8	All	—	c, d, e, h, j
GMAW FCAW	B-U9-GF	U	—	R = 0 to 1/8	α = 30°	f = 1/8	r = 3/8	All	Not required	a, c, d, h, j

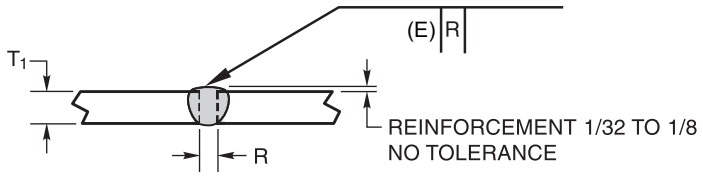
Double-J-groove weld (9)
T-joint (T)
Corner joint (C)



Tolerances	
As Detailed (see 5.4.1.1)	As Fit-Up (see 5.4.1.8
R = +1/16, –0	+1/16, –1/8
α = +10°, –0°	+10°, –5°
f = +1/16, –0	Not Limited
r = 1/8, –0	±1/16

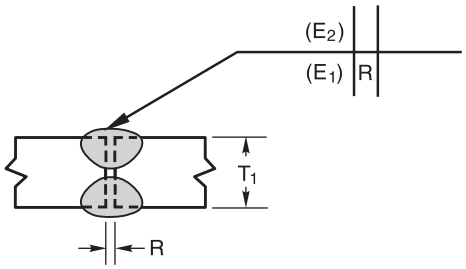
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation				Allowed Welding Positions	Gas Shielding for FCAW	Notes
		T_1	T_2	Root Opening	Groove Angle	Root Face	Bevel Radius			
SMAW	TC-U9a	U	U	R = 0 to 1/8	α = 45°	f = 1/8	r = 3/8	All	—	d, e, g, h, j, k
				R = 0 to 1/8	α = 30°	f = 1/8	r = 3/8	F, OH	—	d, e, g, h, k
GMAW FCAW	TC-U9a-GF	U	U	R = 0 to 1/8	α = 30°	f = 1/8	r = 3/8	All	Not required	a, d, g, h, j, k

Square-groove weld (1)
Butt joint (B)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (S)	Notes
					Tolerances				
		T_1	T_2	Root Opening	As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	B-P1a	1/8	—	R = 0 to 1/16	+1/16, –0	±1/16	All	T_1 – 1/32	b
	B-P1c	1/4 max.	—	R = $\frac{T_1}{2}$ min.	+1/16, –0	±1/16	All	$\frac{T_1}{2}$	b
GMAW FCAW	B-P1a-GF	1/8	—	R = 0 to 1/16	+1/16, –0	±1/16	All	T_1 – 1/32	b, e
	B-P1c-GF	1/4 max.	—	R = $\frac{T_1}{2}$ min.	+1/16, –0	±1/16	All	$\frac{T_1}{2}$	b, e

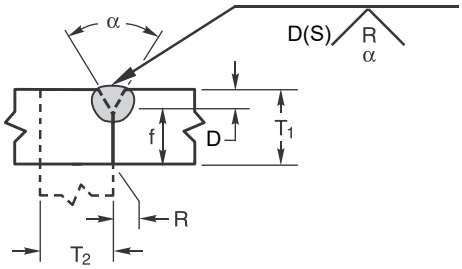
Square-groove weld (1)
Butt joint (B)



$S_1 + S_2$ MUST NOT EXCEED $\frac{3T_1}{4}$

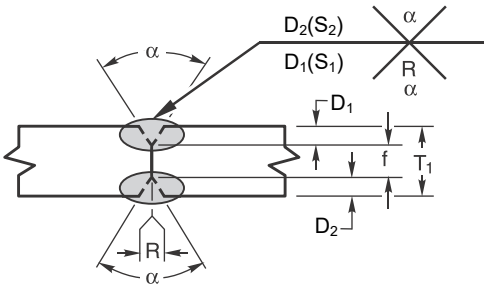
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Total Weld Size ($E_1 + E_2$)	Notes
					Tolerances				
		T_1	T_2	Root Opening	As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	B-P1b	1/4 max.	—	R = $\frac{T_1}{2}$	+1/16, –0	±1/16	All	$\frac{3T_1}{4}$	
GMAW FCAW	B-P1b-GF	1/4 max.	—	R = $\frac{T_1}{2}$	+1/16, –0	±1/16	All	$\frac{3T_1}{4}$	e

Single-V-groove weld (2)
Butt joint (B)
Corner joint (C)



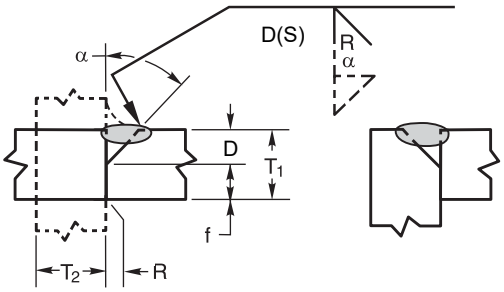
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (S)	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	BC-P2	1/4 min.	U	R = 0 f = 1/32 min. α = 60°	+1/16, –0 +U, –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	All	D	b, e, f, j
GMAW FCAW	BC-P2-GF	1/4 min.	U	R = 0 f = 1/8 min. α = 60°	+1/16, –0 +U, –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	All	D	a, b, f, j
SAW	BC-P2-S	7/16 min.	U	R = 0 f = 1/4 min. α = 60°	±0 +U, –0 +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	D	b, f, j

Double-V-groove weld (3)
Butt joint (B)



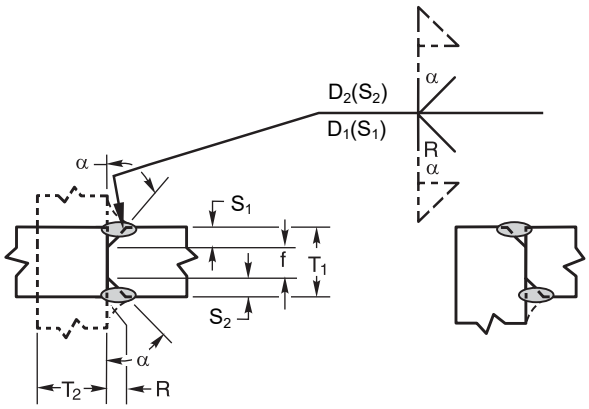
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Total Weld Size ($S_1 + S_2$)	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	B-P3	1/2 min.	—	R = 0 f = 1/8 min. α = 60°	+1/16, –0 +U, –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	All	$D_1 + D_2$	e, f, i, j
GMAW FCAW	B-P3-GF	1/2 min.	—	R = 0 f = 1/8 min. α = 60°	+1/16, –0 +U, –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	All	$D_1 + D_2$	a, f, i, j
SAW	B-P3-S	3/4 min.	—	R = 0 f = 1/4 min. α = 60°	±0 +U, –0 +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	$D_1 + D_2$	f, i, j

Single-bevel-groove weld (4)
Butt joint (B)
T-joint (T)
Corner joint (C)



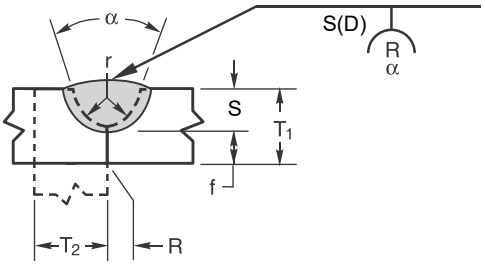
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (S)	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	BTC-P4	U	U	R = 0 f = 1/8 min. α = 45°	+1/16, –0 +U –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	All	D–1/8	b, e, f, g, j, k
GMAW FCAW	BTC-P4-GF	1/4 min.	U	R = 0 f = 1/8 min. α = 45°	+1/16, –0 +U –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	F, H	D	a, b, f, g, j, k
							V, OH	D–1/8	
SAW	TC-P4-S	7/16 min.	U	R = 0 f = 1/4 min. α = 60°	±0 +U, –0 +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	D	b, f, g, j, k

Double-bevel-groove weld (5)
Butt joint (B)
T-joint (T)
Corner joint (C)



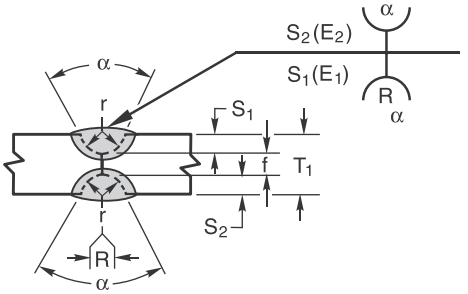
Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Total Weld Size ($S_1 + S_2$)	Notes
				Root Opening Root Face Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	BTC-P5	5/16 min.	U	R = 0 f = 1/8 min. α = 45°	+1/16, –0 +U –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	All	$D_1 + D_2$ –1/4	e, f, g, i, j, k
GMAW FCAW	BTC-P5-GF	1/2 min.	U	R = 0 f = 1/8 min. α = 45°	+1/16, –0 +U –0 +10°, –0°	+1/8, –1/16 ±1/16 +10°, –5°	F, H	$D_1 + D_2$	a, f, g, i, j, k
							V, OH	$D_1 + D_2$ –1/4	
SAW	TC-P5-S	3/4 min.	U	R = 0 f = 1/4 min. α = 60°	±0 +U, –0 +10°, –0°	+1/16, –0 ±1/16 +10°, –5°	F	$D_1 + D_2$	f, g, i, j, k

Single-U-groove weld (6)
Butt joint (B)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (S)	Notes
				Root Opening Root Face Bevel Radius Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	BC-P6	1/4 min.	U	R = 0 f = 1/32 min. r = 1/4 α = 45°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	D	b, e, f, j
GMAW FCAW	BC-P6-GF	1/4 min.	U	R = 0 f = 1/8 min. r = 1/4 α = 20°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	D	a, b, f, j
SAW	BC-P6-S	7/16 min.	U	R = 0 f = 1/4 min. r = 1/4 α = 20°	±0 +U, –0 +1/4, –0 +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5°	F	D	b, f, j

Double-U-groove weld (7)
Butt joint (B)

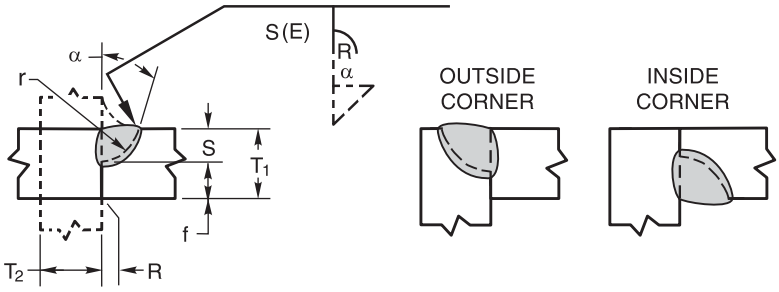


$D_2(S_2)$

D1(S1)

Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Total Weld Size ($S_1 + S_2$)	Notes
				Root Opening Root Face Bevel Radius Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	B-P7	1/2 min.	—	R = 0 f = 1/8 min. r = 1/4 α = 45°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	$D_1 + D_2$	e, f, i, j
GMAW FCAW	B-P7-GF	1/2 min.	—	R = 0 f = 1/8 min. r = 1/4 α = 20°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	$D_1 + D_2$	a, f, i, j
SAW	B-P7-S	3/4 min.	—	R = 0 f = 1/4 min. r = 1/4 α = 20°	±0 +U, –0 +1/4, –0 +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5°	F	$D_1 + D_2$	f, i, j

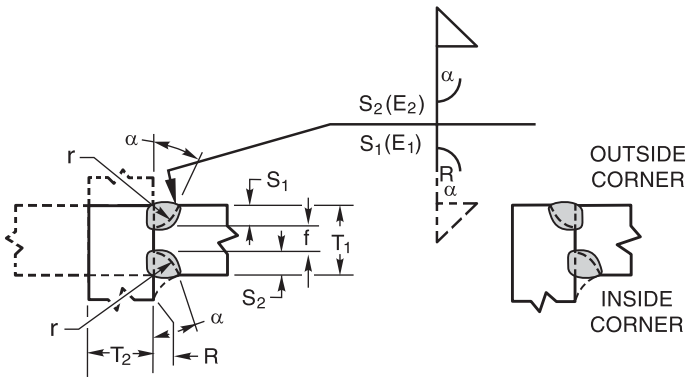
Single-J-groove weld (8)
Butt joint (B)
T-joint (T)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (E)	Notes
				Root Opening Root Face Bevel Radius Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	B-P8	1/4 min.	—	R = 0 f = 1/8 min. r = 3/8 α = 30°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	S	e, f, g, j, k
	TC-P8	1/4 min.	U	R = 0 f = 1/8 min. r = 3/8 α_{oc} = 30°* α_{ic} = 45°**	+1/16, –0 +U, –0 +1/4, –0 +10°, –0° +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5° +10°, –5°	All	S	e, f, g, j, k
GMAW FCAW	B-P8-GF	1/4 min.	—	R = 0 f = 1/8 min. r = 3/8 α = 30°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	S	a, f, g, j, k
	TC-P8-GF	1/4 min.	U	R = 0 f = 1/8 min. r = 3/8 α_{oc} = 30°* α_{ic} = 45°**	+1/16, –0 +U, –0 +1/4, –0 +10°, –0° +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5° +10°, –5°	All	S	a, f, g, j, k
SAW	B-P8-S	7/16 min.	—	R = 0 f = 1/4 min. r = 1/2 α = 20°	±0 +U, –0 +1/4, –0 +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5°	F	S	f, g, j, k
	TC-P8-S	7/16 min.	U	R = 0 f = 1/4 min. r = 1/2 α_{oc} = 20°* α_{ic} = 45°**	±0 +U, –0 +1/4, –0 +10°, –0° +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5° +10°, –5°	F	S	f, g, j, k

*α_{oc} = Outside corner groove angle.
**α_{ic} = Inside corner groove angle.

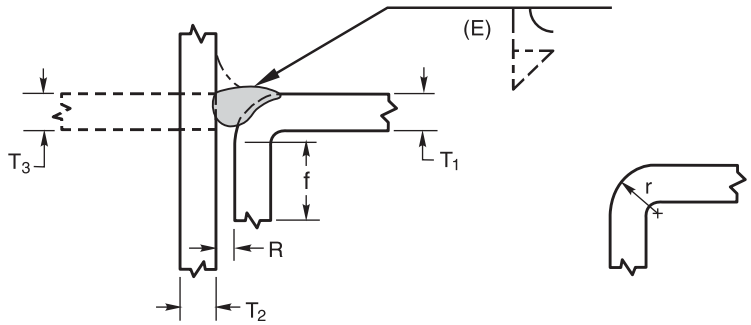
Double-J-groove weld (9)
Butt joint (B)
T-joint (T)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Total Weld Size ($E_1 + E_2$)	Notes
				Root Opening Root Face Bevel Radius Groove Angle	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW	B-P9	1/2 min.	—	R = 0 f = 1/8 min. r = 3/8 α = 30°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	$S_1 + S_2$	e, f, g, i, j, k
	TC-P9	1/2 min.	U	R = 0 f = 1/8 min. r = 3/8 α_{oc} = 30°* α_{ic} = 45°**	+1/16, –0 +U, –0 +1/4, –0 +10°, –0° +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5° +10°, –5°	All	$S_1 + S_2$	e, f, g, i, j, k
GMAW FCAW	B-P9-GF	1/2 min.	—	R = 0 f = 1/8 min. r = 3/8 α = 30°	+1/16, –0 +U, –0 +1/4, –0 +10°, –0°	+1/8, –1/16 ±1/16 ±1/16 +10°, –5°	All	$S_1 + S_2$	a, f, g, i, j, k
	TC-P9-GF	1/2 min.	U	R = 0 f = 1/8 min. r = 3/8 α_{oc} = 30°* α_{ic} = 45°**	±0 +U, –0 +1/4, –0 +10°, –0° +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5° +10°, –5°	All	$S_1 + S_2$	a, f, g, i, j, k
SAW	B-P9-S	3/4 min.	—	R = 0 f = 1/4 min. r = 1/2 α = 20°	±0 +U, –0 +1/4, –0 +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5°	F	$S_1 + S_2$	f, g, i, j, k
	TC-P9-S	3/4 min.	U	R = 0 f = 1/4 min. r = 1/2 α_{oc} = 20°* α_{ic} = 45°**	±0 +U, –0 +1/4, –0 +10°, –0° +10°, –0°	+1/16, –0 ±1/16 ±1/16 +10°, –5° +10°, –5°	F	$S_1 + S_2$	f, g, i, j, k

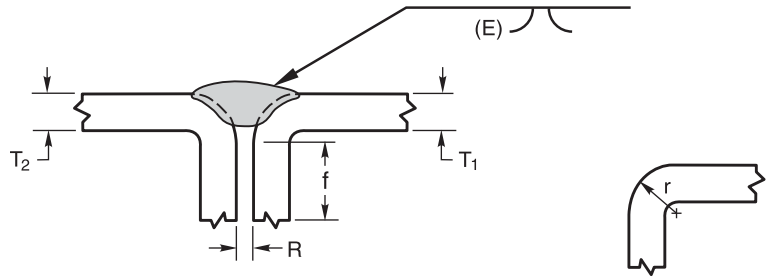
*α_{oc} = Outside corner groove angle.
**α_{ic} = Inside corner groove angle.

Flare-bevel-groove weld (10)
Butt joint (B)
T-joint (T)
Corner joint (C)



Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)			Groove Preparation			Allowed Welding Positions	Weld Size (E)	Notes
					Root Opening Root Face Bend Radius	Tolerances				
		T_1	T_2	T_3		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7			
SMAW FCAW-S	BTC-P10	3/16 min.	U	T_1 min.	R = 0 f = 3/16 min. $r = \frac{3T_1}{2}$ min.	+1/16,-0 +U, –0 +U,-0	+1/8,-1/16 +U, -1/16 +U,-0	All	5/16 r	e, g, j, l
GMAW FCAW-G	BTC-P10-GF	3/16 min.	U	T_1 min.	R = 0 f = 3/16 min. $r = \frac{3T_1}{2}$ min.	+1/16,-0 +U, –0 +U,-0	+1/8,-1/16 +U, -1/16 +U,-0	All	5/8 r	a, g, j, l, m
SAW	B-P10-S	1/2 min.	N/A	1/2 min.	R = 0 f = 3/16 min. $r = \frac{3T_1}{2}$ min.	+1/16,-0 +U, –0 +U,-0	+1/8,-1/16 +U, -1/16 +U,-0	F	5/16 r	g, j, l, m

Flare-V-groove weld (11)
Butt joint (B)

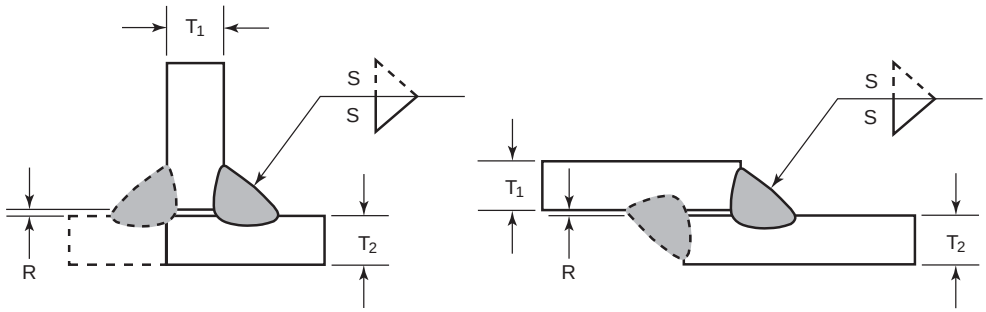


Welding Process	Joint Designation	Base Metal Thickness (U = unlimited)		Groove Preparation			Allowed Welding Positions	Weld Size (E)	Notes
				Root Opening Root Face Bend Radius	Tolerances				
		T_1	T_2		As Detailed (see 5.4.2.2)	As Fit-Up (see 5.4.2.7)			
SMAW FCAW-S	B-P11	3/16 min.	T_1 min.	R = 0 f = 3/16 min. $r = \frac{3T_1}{2}$ min.	+1/16, -0 +U, -0 +U,-0	+1/8,-1/16 +U,-1/16 +U, -0	All	5/8 r	e, j, l, m, n
GMAW FCAW-G	B-P11-GF	3/16 min.	T_1 min.	R = 0 f = 3/16 min. $r = \frac{3T_1}{2}$ min.	+1/16, -0 +U, -0 +U,-0	+1/8,-1/16 +U,-1/16 +U, -0	All	3/4 r	a, j, l, m, n
SAW	B-P11-S	1/2 min.	T_1 min.	R = 0 f = 3/16 min. $r = \frac{3T_1}{2}$ min.	+1/16, -0 +U, -0 +U,-0	+1/8,-1/16 +U,-1/16 +U, -0	F	1/2 r	j, l, m, n

Notes

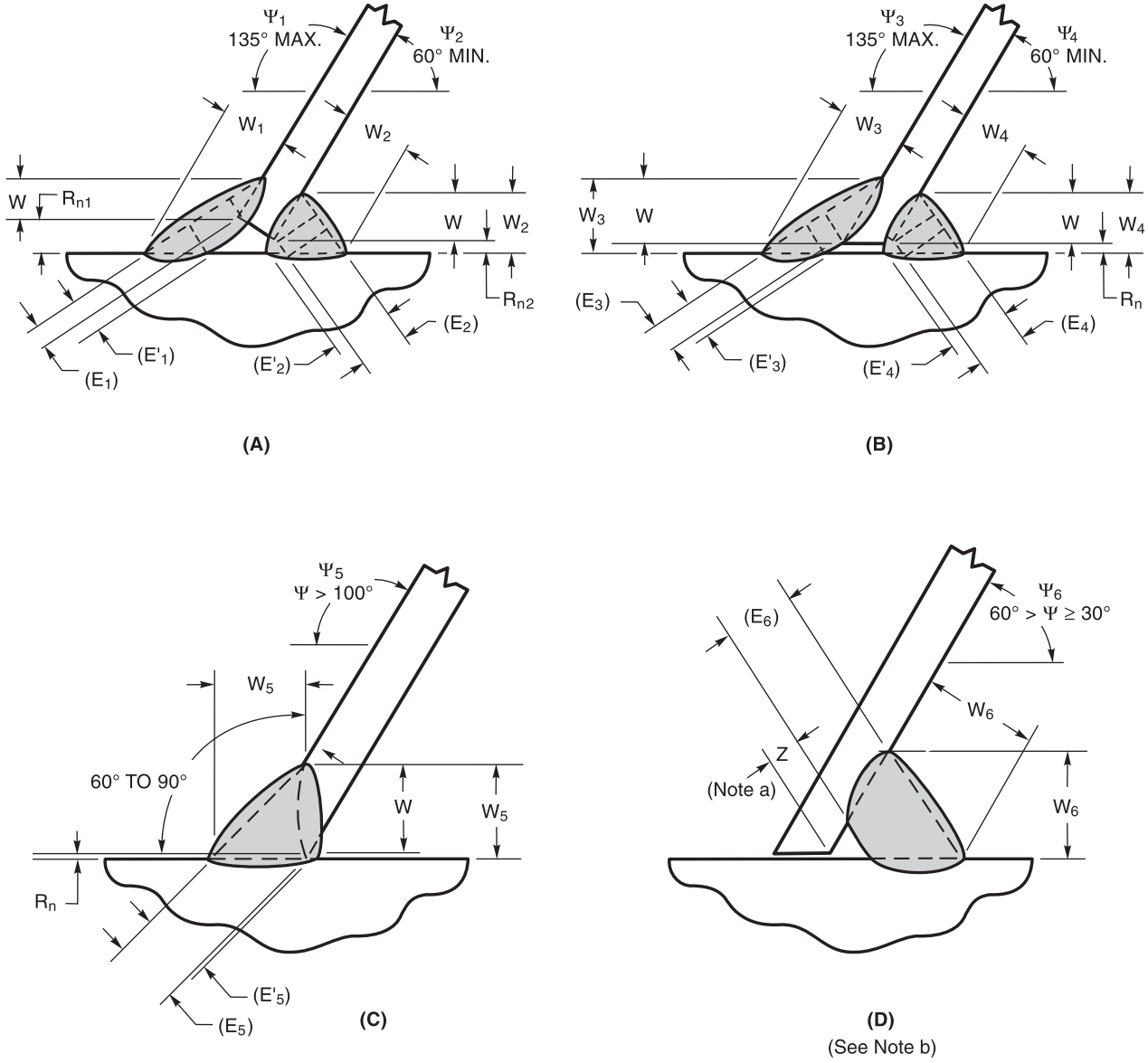
[a] Fillet weld size (“S”). See 4.4.2.8 and Clause 7.13 for minimum fillet weld sizes. See Table 5.1 for maximum single pass size.
[b] See 7.21.1 for additional fillet weld assembly requirements or exceptions.
[c] See 4.4.2.9 for maximum weld size in lap joints.
[d] Perpendicularity of the members shall be within ±10°.

Fillet weld (12)
T-joint (T)
Corner joint (C)
Lap joint (L)



ALL DIMENSIONS IN inches

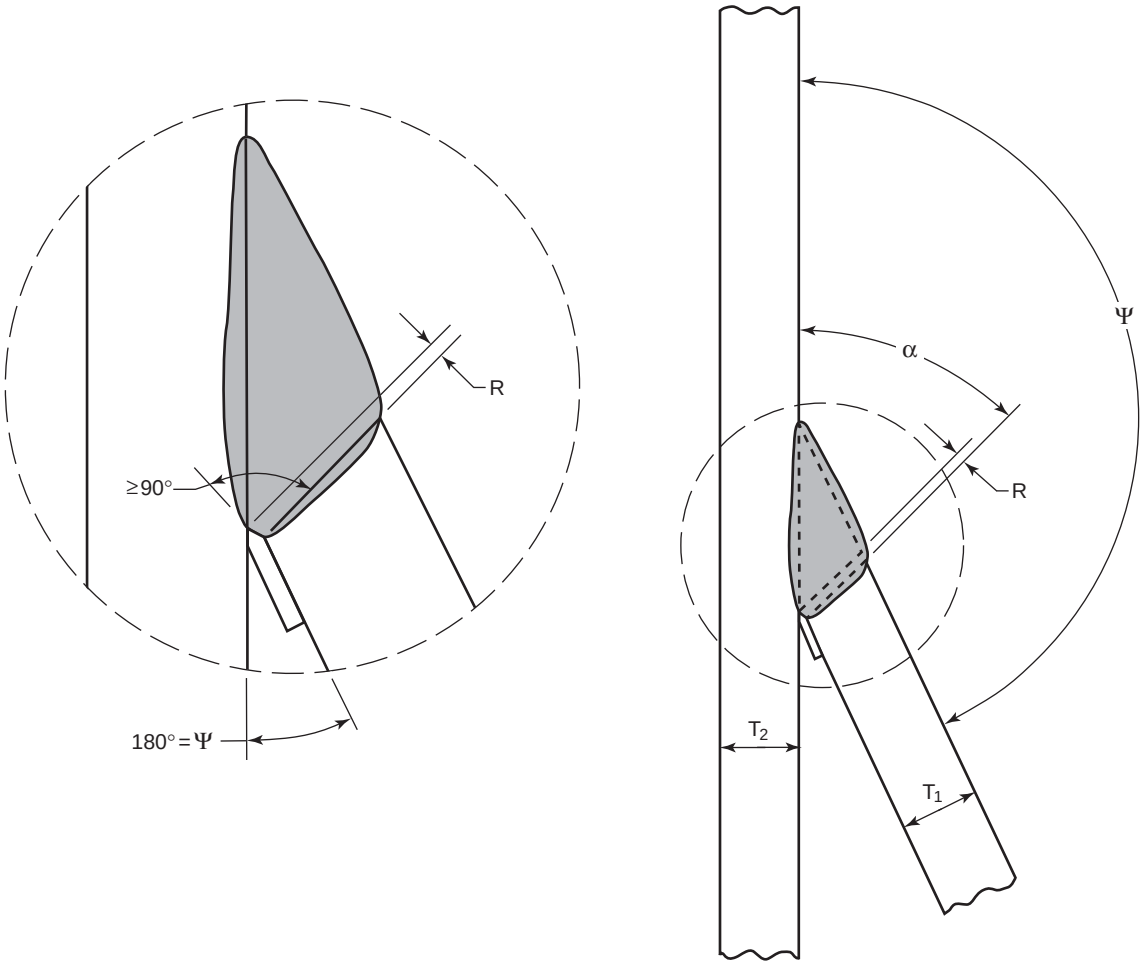
Welding Process	Joint Designation	Base Metal Thickness	Joint Design/Geometry			Allowed Welding Positions	Notes
				Tolerances			
		T_1 or T_2	Root Opening	As Detailed	As Fit-Up		
SMAW	TC-F12	<3	R = 0	+1/16, –0	3/16 max.	All	a, b, d
	TC-F12a	≥3			5/16 max.		a, b, d
	L-F12	<3			3/16 max.		a, b, c
	L-F12a	≥3			5/16 max.		a, b, c
GMAW FCAW	TC-F12-GF	<3	R = 0	+1/16, –0	3/16 max.	All	a, b, d
	TC-F12a-GF	≥3			5/16 max.		a, b, d
	L-F12-GF	<3			3/16 max.		a, b, c
	L-F12a-GF	≥3			5/16 max.		a, b, c
SAW	TC-F12-S	<3	R = 0	+1/16, –0	3/16 max.	F, H	a, b, d
	TC-F12a-S	≥3			5/16 max.		a, b, d
	L-F12-S	<3			3/16 max.		a, b, c
	L-F12a-S	≥3			5/16 max.		a, b, c



[a] Detail (D). Apply Z loss dimension of Table 4.2 to determine effective throat.
[b] Detail (D) shall not be prequalified for under 30°. For welder qualifications, see Table 6.10.

Notes:

1. (En), (E'n) = Effective throats dependent on magnitude of root opening (Rn) (see 7.21.1). (n) represents 1 through 5.
2. t = thickness of thinner part
3. Not prequalified for GMAW-S or GTAW.



Note: 90° ≤ Ψ ≤ 170°.

INNERSHIELD® NR®-232

Mild Steel, All Position ▪ AWS E71T-8, E71T8-A2-CS3-H16

KEY FEATURES

- High deposition rates for out-of-position welding
- Penetrating arc
- Fast freezing, easy to remove slag system
- Meets AWS D1.8 seismic lot waiver requirements

WELDING POSITIONS

All

TYPICAL APPLICATIONS

- Structural fabrication, including those subject to seismic requirements
- General plate fabrication
- Hull plate and stiffener welding on ships and barges
- Machinery parts, tanks, hoppers, racks and scaffolding

CONFORMANCES

AWS A5.20/A5.20M:	E71T-8-H16
AWS A5.36:	E71T8-A2-CS3-H16
ASME SFA-A5.20:	E71T-8-H16
ABS:	3YSA
Lloyd's Register:	3YS H15
DNV Grade:	III YMS H15
GL:	3YH10S
BV Grade:	SA3YMH
CWB/CSA W48-06:	E491T-8 H16
DB:	EN 758 T42 3 Y N 2
TUV:	EN 758 T42 3 Y N 2
MIL-E-24403/1:*	MIL-71T-8AS
FEMA 353	
AWS D1.8	
JIS Z 3313	T49T38-1NA-H15

**Military Grade Classification of MIL-71T-8AS for 0.068 in (1.7 mm) and 0.072 in (1.8 mm) diameters only.*

DIAMETERS / PACKAGING

Diameter in (mm)	13.5 lb (6.1 kg) Coil 54 lb (24.5 kg) Master Carton	13.5 lb (6.1 kg) Coil 54 lb (24.5 kg) Hermetically Sealed Pail	25 lb (11.3 kg) Steel Spool
0.068 (1.7)	ED012518	ED030232	ED030643
0.072 (1.8)	ED012522		ED030644
5/64 (2.0)	ED012525		ED030647

Diameter in (mm)	25 lb (11.3 kg) Plastic Spool (Vacuum Sealed Foil Bag)	50 lb (22.7 kg) Coil
0.068 (1.7)	ED030949	ED012519
0.072 (1.8)		ED012523
5/64 (2.0)		ED012526

MECHANICAL PROPERTIES[1]

	Yield Strength[2] MPa (ksi)	Tensile Strength MPa (ksi)	Elongation %	Hardness Rockwell B	Charpy V-Notch / J ft•lbf) @ -29°C (-20°F)
Requirements - AWS E71T-8	400 (58) min	480-655 (70-95)	22 min	–	27 (20) min
Typical Results[3] - As-Welded	460-520 (66-75)	575-615 (83-89)	25-31	87-90	47-75 (35-55)

[1]Typical all weld metal. [2]Measured with 0.2% offset. [3]See test results disclaimer
NOTE: FEMA 353 and AWS D1.8 structural steel seismic supplement test data can be found on this product at www.lincolnelectric.com.

DEPOSIT COMPOSITION[1]

	%C	%Mn	%Si	%S	%P	%Al
Requirements - AWS E71T-8	0.30 max	1.75 max	0.60 max	0.03 max	0.03 max	1.8 max
Typical Results[3]	0.16-0.18	0.61-0.72	0.26-0.33	≤0.01	≤0.01	0.5-0.8

TYPICAL OPERATING PROCEDURES

Diameter, Polarity	CTWD[6] mm (in)	Wire Feed Speed m/min (in/min)	Voltage[7] (volts)	Approx. Current (amps)	Melt-Off Rate kg/hr (lb/hr)	Deposition Rate kg/hr (lb/hr)	Efficiency (%)
0.068 in (1.7 mm), DC-	19-32 (3/4-1 1/4)	2.8 (110)	18-19	195	2.3 (5.0)	1.8 (3.9)	78
		3.3 (130)	19-21	225	2.8 (6.2)	2.0 (4.6)	74
		3.8 (150)	19-21	250	3.2 (7.1)	2.4 (5.3)	75
		4.3 (170)	20-22	270	3.5 (7.8)	2.8 (6.1)	78
		5.0 (195)	23-24	300	4.3 (9.4)	3.2 (7.0)	74
30-73.1 02 Jan 2020		6.4 (250)	23-24	350	5.4 (11.8)	4.0 (9.0)	76
		7.4 (320)	25-27	400	6.9 (15.2)	5.2 (11.4)	75
0.072 in (1.8 mm), DC-	19-32 (3/4-1 1/4)	2.0 (80)	16-18	130	1.8 (4.0)	1.5 (3.3)	83
		3.5 (140)	18-21	225	3.1 (6.8)	2.5 (5.5)	81
		3.9 (155)	19-22	240	3.3 (7.2)	2.7 (6.0)	83
		4.3 (170)	20-23	255	3.6 (8.0)	2.9 (6.5)	81
		6.4 (250)	22-24	315	5.3 (11.7)	4.3 (9.6)	82
30.4-72.9 January, 02 2020		7.4 (290)	23-25	350	6.2 (13.6)	5.0 (11.0)	81
5/64 in (2.0 mm), DC-	19-32 (3/4-1 1/4)	1.5 (60)	16-17	145	1.7 (3.7)	1.2 (2.7)	73
		2.9 (115)	19-20	260	3.2 (7.0)	2.5 (5.5)	78
		3.0 (120)	19-20	270	3.3 (7.3)	2.6 (5.7)	78
		3.3 (130)	20-21	285	3.5 (7.8)	2.8 (6.2)	79
33.2-81.6 02 Jan 2020		4.6 (180)	22-23	365	5.0 (10.9)	3.9 (8.7)	80

[1]Typical all weld metal. [2]Measured with 0.2% offset. [3]See test results disclaimer
NOTE: FEMA 353 and AWS D1.8 structural steel seismic supplement test data can be found on this product at www.lincolnelectric.com.

Material Safety Data Sheets (MSDS) and Certificates of Conformance are available on our website at www.lincolnelectric.com

TEST RESULTS

Test results for mechanical properties, deposit or electrode composition and diffusible hydrogen levels were obtained from a weld produced and tested according to prescribed standards, and should not be assumed to be the expected results in a particular application or weldment. Actual results will vary depending on many factors, including, but not limited to, weld procedure, plate chemistry and temperature, weldment design and fabrication methods. Users are cautioned to confirm by qualification testing, or other appropriate means, the suitability of any welding consumable and procedure before use in the intended application.

CUSTOMER ASSISTANCE POLICY

The Lincoln Electric Company is manufacturing and selling high quality welding equipment, consumables, and cutting equipment. Our challenge is to meet the needs of our customers and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for information or advice about their use of our products. Our employees respond to inquiries to the best of their ability based on information provided to them by the customers and the knowledge they may have concerning the application. Our employees, however, are not in a position to verify the information provided or to evaluate the engineering requirements for the particular weldment. Accordingly, Lincoln Electric does not warrant or guarantee or assume any liability with respect to such information or advice. Moreover, the provision of such information or advice does not create, expand, or alter any warranty on our products. Any express or implied warranty that might arise from the information or advice, including any implied warranty of merchantability or any warranty of fitness for any customers' particular purpose is specifically disclaimed.

Lincoln Electric is a responsive manufacturer, but the selection and use of specific products sold by Lincoln Electric is solely within the control of, and remains the sole responsibility of the customer. Many variables beyond the control of Lincoln Electric affect the results obtained in applying these types of fabrication methods and service requirements.

Subject to Change – This information is accurate to the best of our knowledge at the time of printing. Please refer to www.lincolnelectric.com for any updated information.

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CERTIFICATE OF CONFORMANCE

LINCOLN ELECTRIC
THE WELDING EXPERTS®

Electrode: **Innershield® NR®-232**
Electrode Size **.068" (1.7 mm)**
Specification: **AWS D1.8:2016**
Date: **March 01, 2022**

This is to certify that the above listed product was manufactured to meet the Class T4 requirement of AWS A5.01 as required by clause 6.3.1.2 of AWS D1.8:2016.

It was manufactured and supplied according to a Quality System Program that meets the requirements of ISO9001 among others as documented on The Lincoln Electric web page (<http://www.lincolnelectric.com/en-us/company/Pages/certifications.aspx>).

Operating Settings	High Heat Input Requirements	Low Heat Input Requirements	High Heat Input Results	Low Heat Input Results
Electrode Lot			17243115	17243115
Base Material			ASTM A572 steel (Grade 50)	ASTM A572 steel (Grade 50)
Current Type/Polarity			DC-	DC-
Plate Thickness, mm (in)	(3/4)	(3/4)	19 (3/4)	19 (3/4)
Nominal Voltage, V			20	22
Wire Feed Speed, cm/min (in/min)			381 (150)	508 (200)
Nominal Current, A			240	285
Average Heat Input, kJ/mm (kJ/in)	Not Specified	Not Specified	2.9 (73.2)	1.2 (30.8)
Travel Speed, cm/min (in/min)			10 (3.9)	31 (12.2)
Contact Tip to Work Distance, mm (in)			25 (1)	25 (1)
Pass/Layers			8/5	18/6
Preheat Temperature, °C (°F)	(250 min.)	(120 max.)	135 (275)	20 (70)
Interpass Temperature, °C (°F)	(450 min.)	(250 max.)	230 (450)	120 (250)
Postweld Heat Treatment	As-welded	As-welded	As-welded	As-welded
Weld Position			3G	1G

Mechanical properties of weld deposits

Tensile Strength, MPa (ksi)	(70 min.)	(70 min.)	600 (88)	610 (88)
Yield Strength, 0.2% Offset, MPa (ksi)	(58 min.)	(58 min.)	450 (65)	470 (69)
Elongation %	22 min.	22 min.	27	27
Average Impact Energy Joules @ -18 °C (ft-lbs @ 0 °F)	(40 min.)	(40 min.)	63 (46) 59,63,65 (44,47,48)	65 (48) 62,64,67 (46,47,50)

1. This document meets the requirements of AWS A5.01M/A5.01 Schedule F. When a specific lot number is referenced it also meets the requirements of EN10204, type 2.2. It does not meet the requirements of type 3.1.
2. This product satisfies the requirements of AWS D1.8:2016, Annex E, after exposure for 1 week at 80°F / 80% relative humidity.
3. The Charpy V-notch impact values reported at -18 °C (0 °F) are required when the Lowest Anticipated Service Temperature (LAST) is -29 °C (-20 °F).
4. Lot testing exemption as defined in AWS D1.8/D1.8M: 6.3.3 by testing a minimum of 3 lots for approval has been completed. For further questions please contact customer service. https://www.lincolnelectric.com/en/Ask-the-Experts/Contact-Us
5. The strength and elongation properties reported here were obtained from tensile specimens artificially aged at 105°C (220°F) for 48 hours.
6. Strength values in SI units are reported to the nearest 10 MPa converted from actual data. Preheat and interpass temperature values in SI units are reported to the nearest 5 degrees.

March 01, 2022
Daniel Gaul, Certification Supervisor — Date

Radhika Panday — March 07, 2022
Radhika Panday, Manager, Consumable Compliance Designee — Date

Cert. No. 22320-5