NASCC: THE **STEEL** CONFERENCE

WELDING SYMBOLS AND PRESENTATION FOR DESIGNERS AND DETAILERS

(N72)

PRESENTER:

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LBYD, INC.
BIRMINGHAM, AL

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HOW TO DESIGN AND DETAIL

(CORRECT PRESENTATION)

WELD SYMBOLS FOR SHOP AND FIELD

ECONOMY AND TO ACCURATELY

CONVEY WHAT YOU MEAN.

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WHY IS IT IMPORTANT TO UNDERSTAND & ACCURATELY SHOW WELD SYMBOLS?

ANSWER:

BECAUSE THEY TIE THE DESIGN INTENT WITH THE ACTUAL FABRICATION AND MANUFACTURING PROCESS.

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OUTLINE

1. BASIC WELD TYPES & SYMBOLS.
2. COMMON WELD PROCESSES & POSITIONS.
3. BASIC WELD DESIGN.
4. CORRECT WELD SYMBOLS & PLACEMENT.
5. WELD ECONOMY.
6. SPECIAL TOPICS.

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BASIC WELD TYPES
&
SYMBOLS

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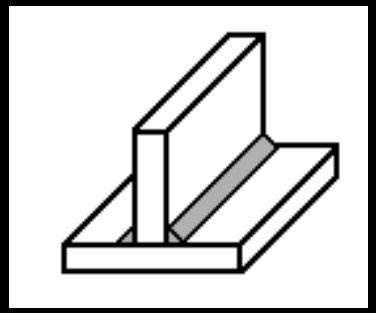
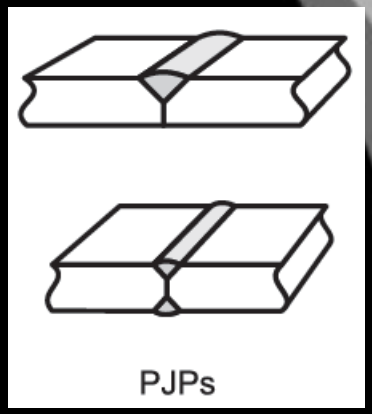
Basic Weld Types & Symbols

- BASIC WELD TYPES:



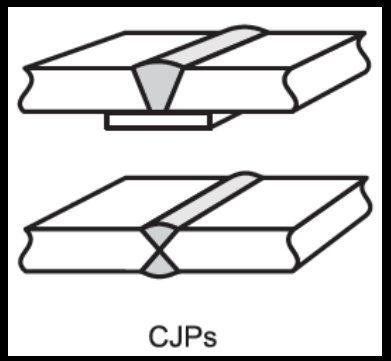


Fillet Welds

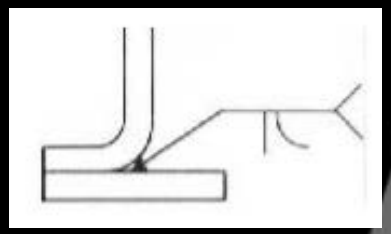
Groove Welds:

- Partial Joint Penetration (PJP)

- Complete Joint Penetrations (CJP)

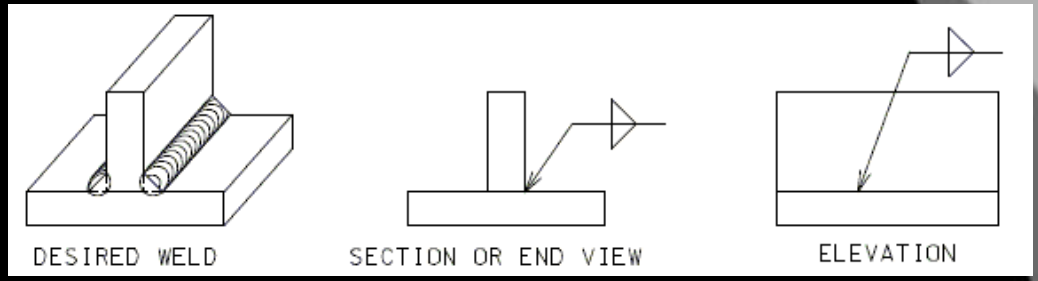


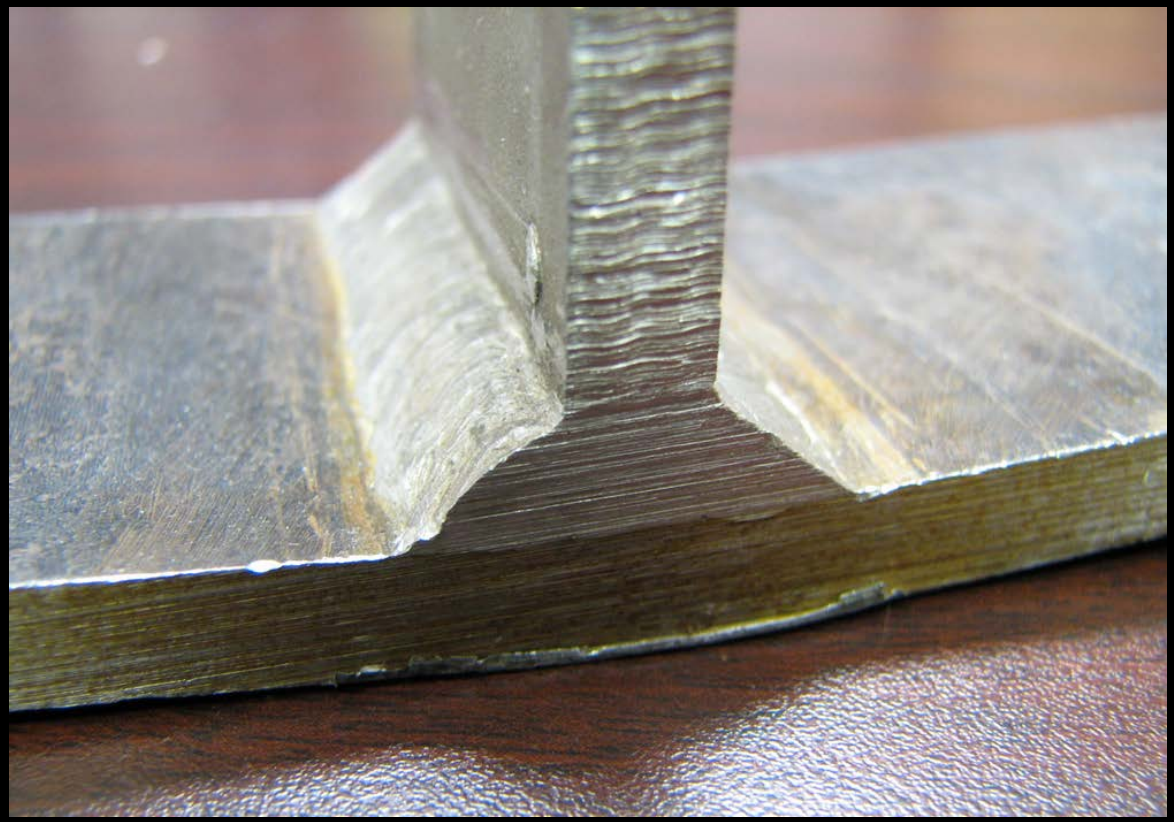
- Flare-Bevel Groove Weld



Basic Weld Types & Symbols

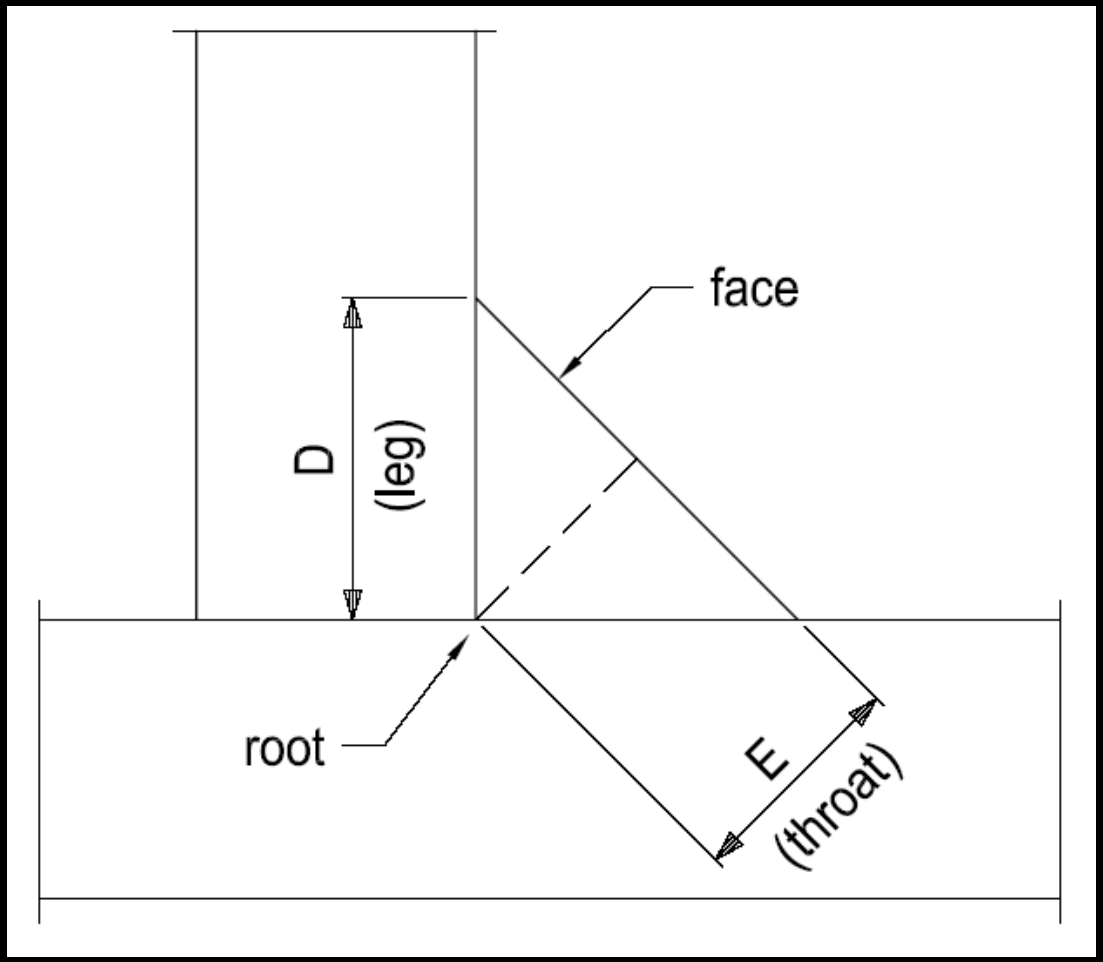
- FILLET WELDS:





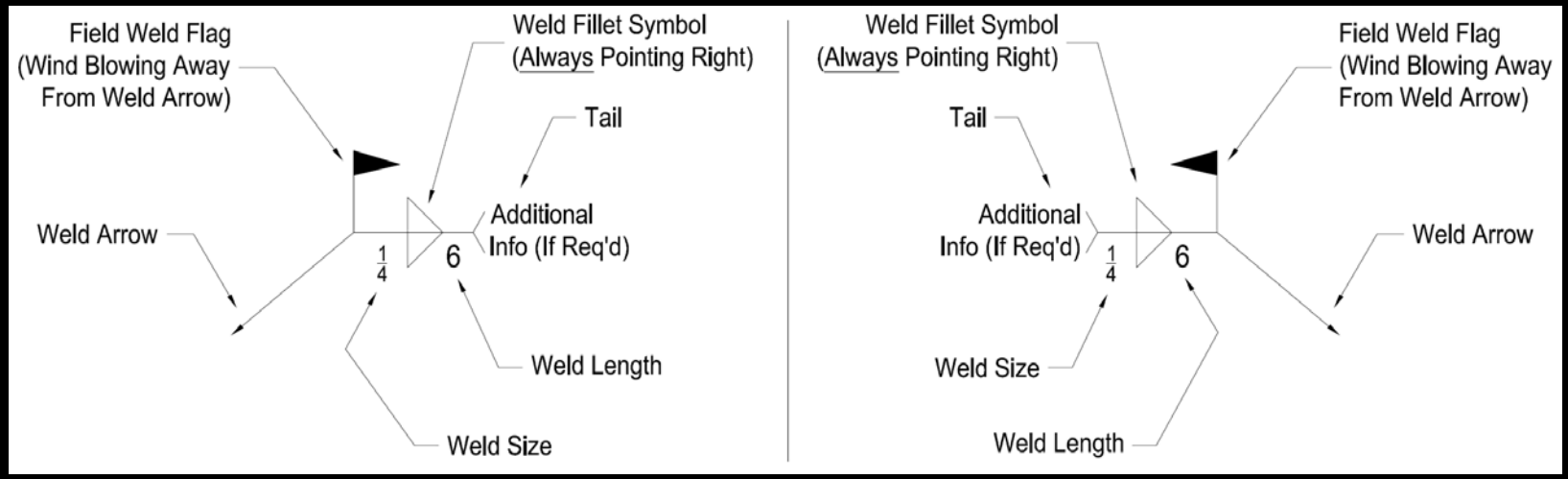
Basic Weld Types & Symbols

- BASIC FILLET WELD SYMBOLS:



Basic Weld Types & Symbols

- BASIC FILLET WELD SYMBOLS:



FILLET WELDS

Basic Weld Types & Symbols

- BASIC GROOVE WELD SYMBOLS:

AWS D1.1 =>

Symbols for Weld Types:	Symbols for Joint Types:	Symbols for Weld Process:	Symbols for Base Metal Thickness and Penetration:
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 Groove 11 Flare Groove (Open Root) 12 Flare Bevel Fillet	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	F for FCAW G for GMAW sc for Short Circuit S for SAW Not any of the above=SMAW or GTAW	U=Unlimited Thickness, Complete Joint Penetration L=Limited Thickness, Complete Joint Penetration P=Partial Joint Penetration

Be Familiar With & Always Show Process for Full or Partial Penetration Welds.

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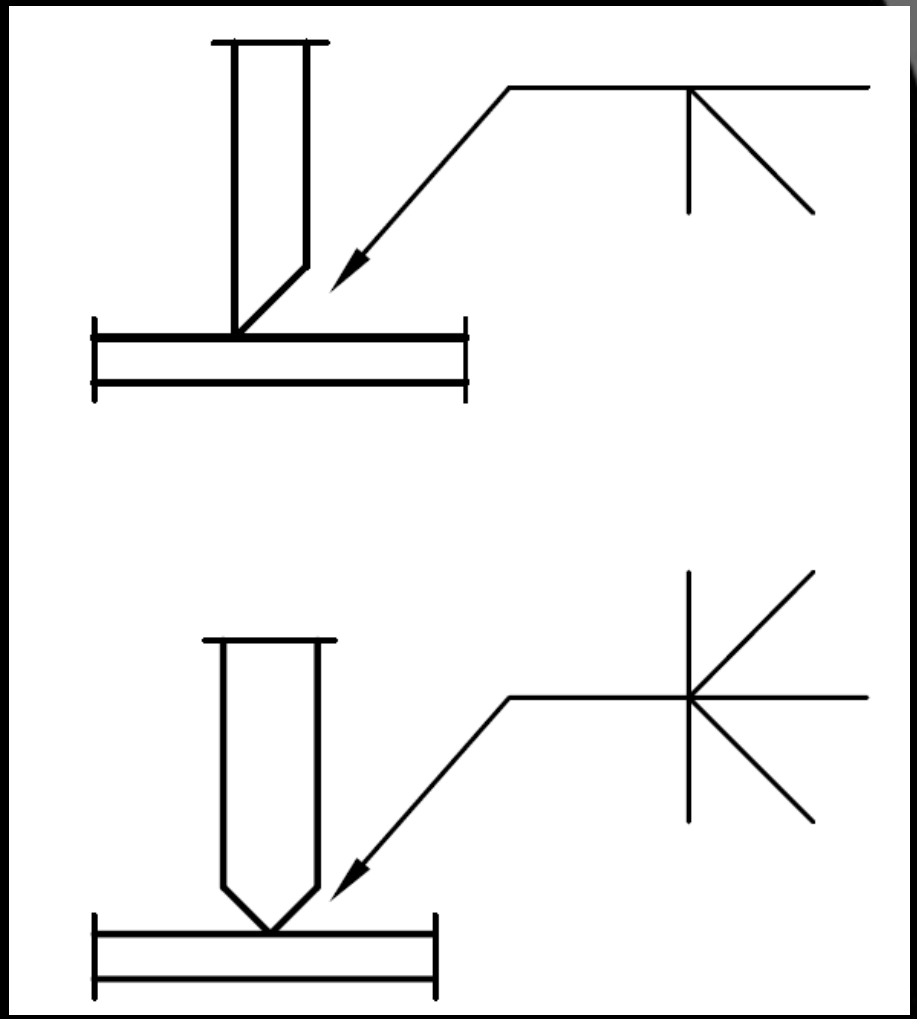
Basic Weld Types & Symbols

- DEFINITION OF ‘GROOVE’:

SINGLE-BEVEL GROOVE

DOUBLE-BEVEL GROOVE



Basic Weld Types & Symbols

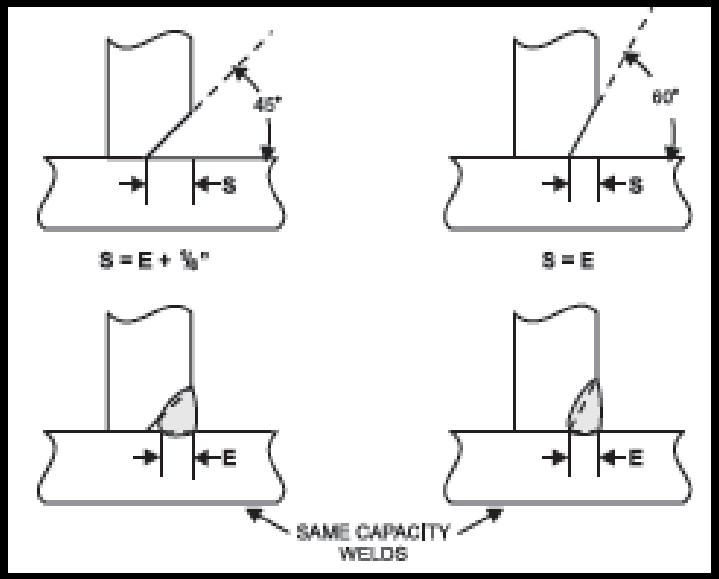
COMMON GROOVE WELDS IN STRUCTURAL STEEL:

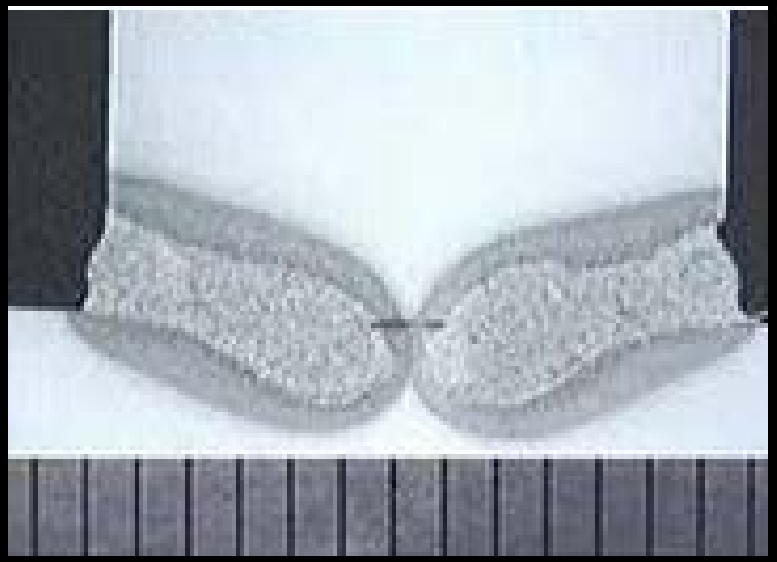
- BTC-P4
- TC-U4a
- B-U4a, or, B-U4b
- BTC-P10

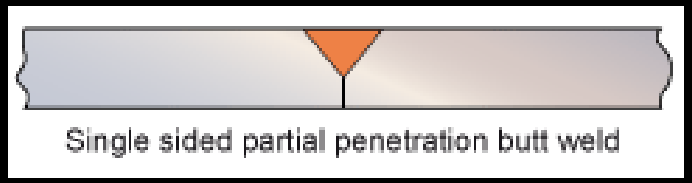
95%

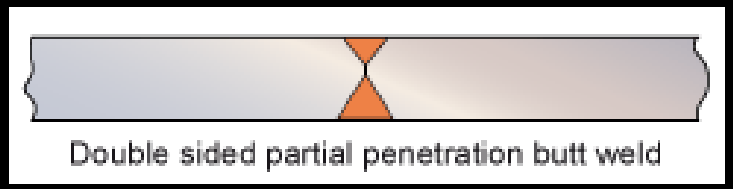
Basic Weld Types & Symbols

- PARTIAL JOINT PENETRATION WELDS:









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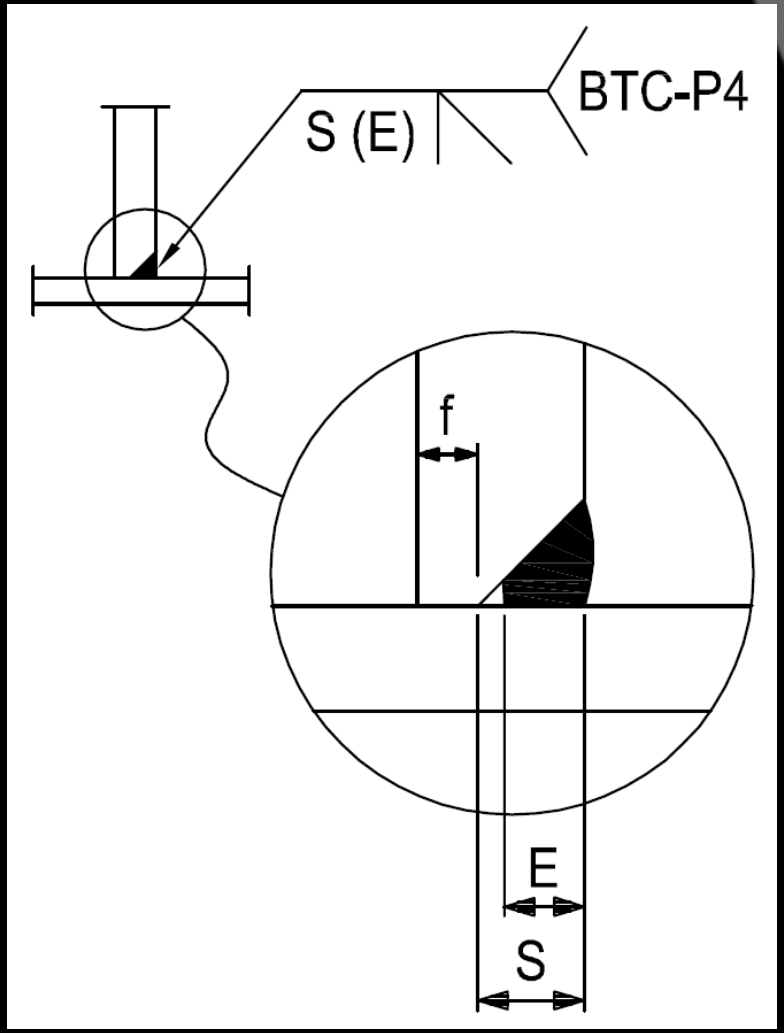
Basic Weld Types & Symbols

- BTC-P4:

E = Effective Throat

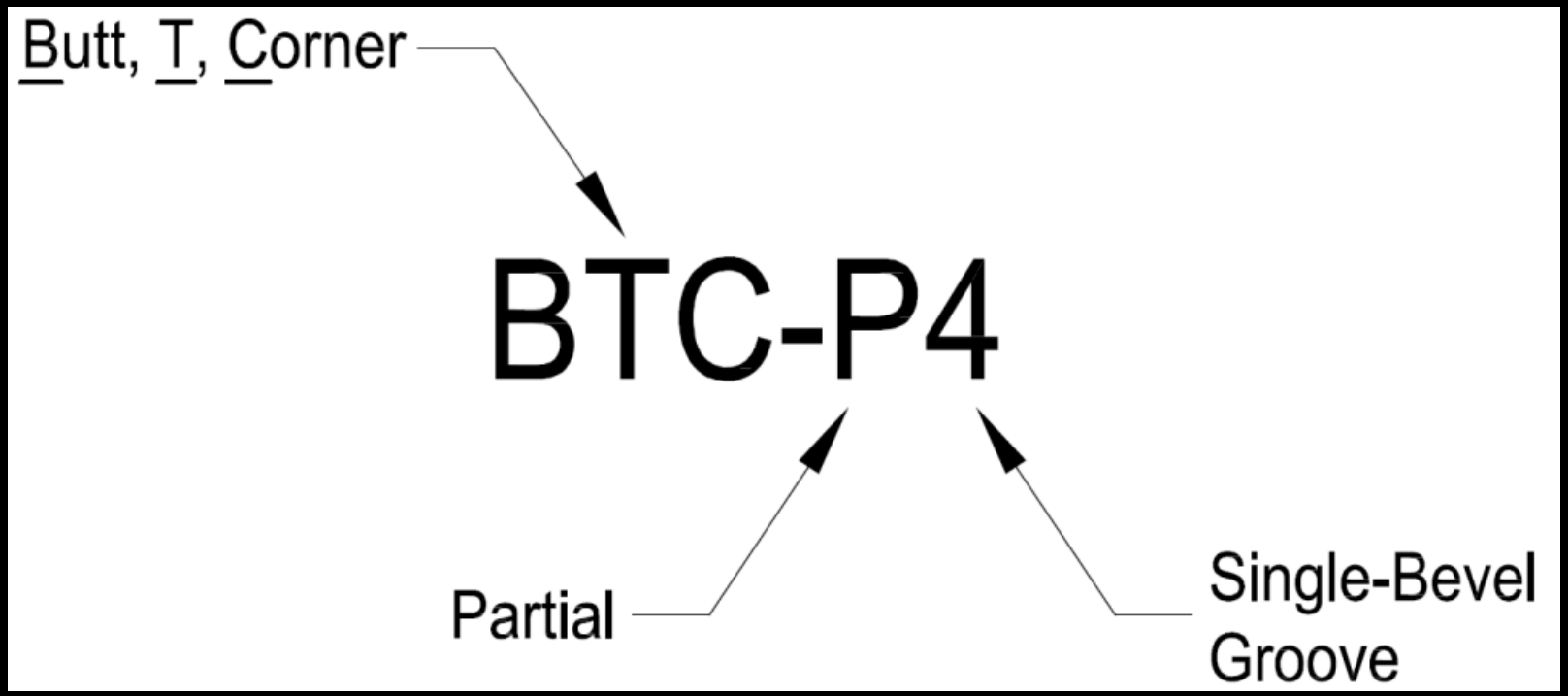
S = Preparation (Bevel)

f = Land, 1/8” (Min.)



Basic Weld Types & Symbols

- BTC-P4 JOINT DESIGNATION:



Basic Weld Types & Symbols

- BASIC GROOVE WELD SYMBOLS:

AWS D1.1 =>

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Be Familiar With & Always Show Process for Full or Partial Penetration Welds.

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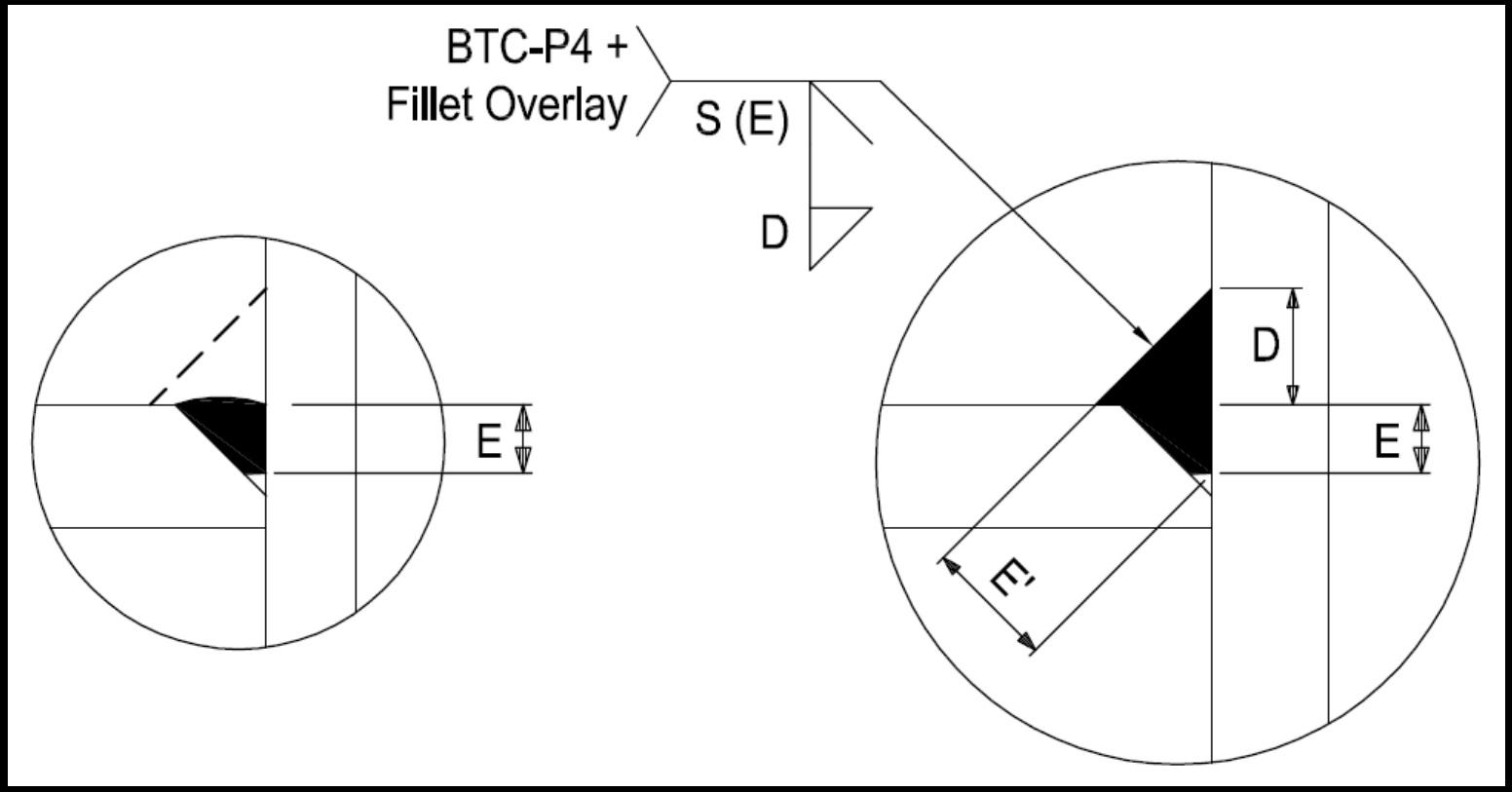
Basic Weld Types & Symbols

- SPECIAL TOPIC : Fillet ‘Overlay’ for PJP:



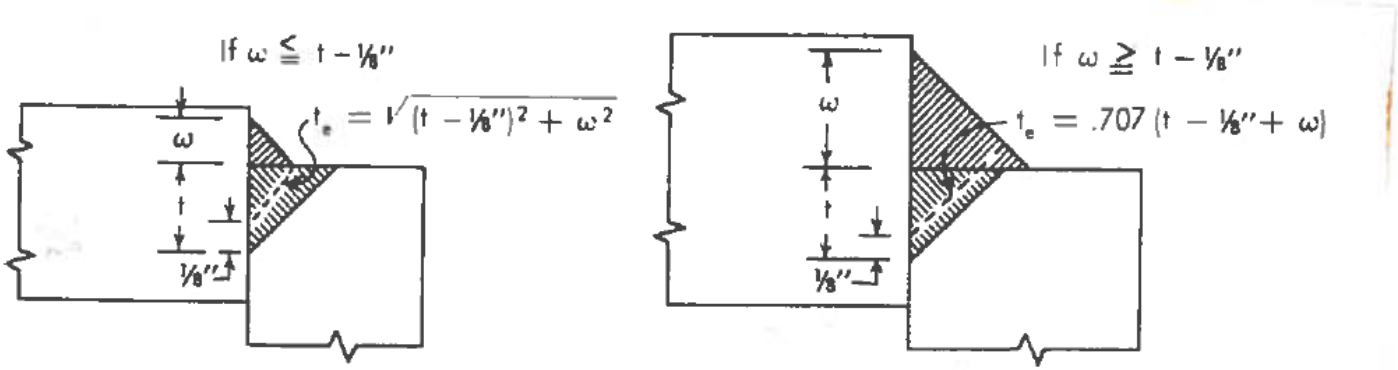
Basic Weld Types & Symbols

- SPECIAL TOPIC : Fillet 'Overlay' for PJP:

FILLET REINFORCING (OVERLAYS)

$$\begin{cases} w \le (t - \frac{1}{8}") \sim t_e = \sqrt{(t - \frac{1}{8}")^2 + w^2} \\ w \ge (t - \frac{1}{8}") \sim t_e = 0.7071\left[(t - \frac{1}{8}") + w\right] \end{cases}$$

BLODGETT p. 3.6-4



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Basic Weld Types & Symbols

- BTC-P10:

E = Effective Throat

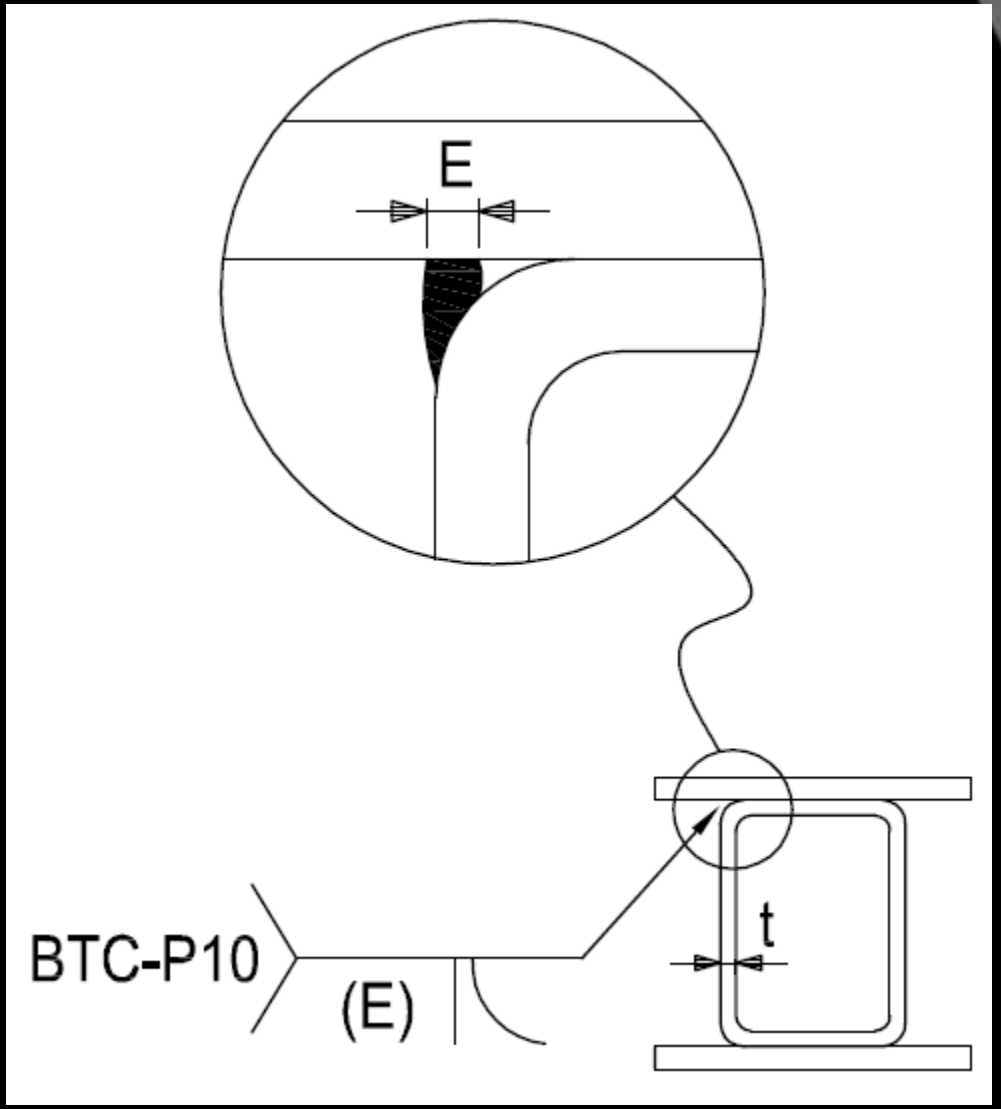
E_{max} = 5/8 t

For t_{hss} = 3/8”

E = (0.93) 5/8 (3/8”)

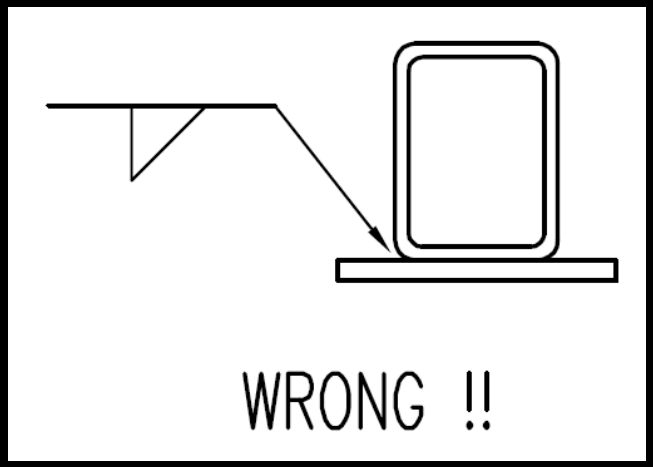
E = 0.218” (Design)

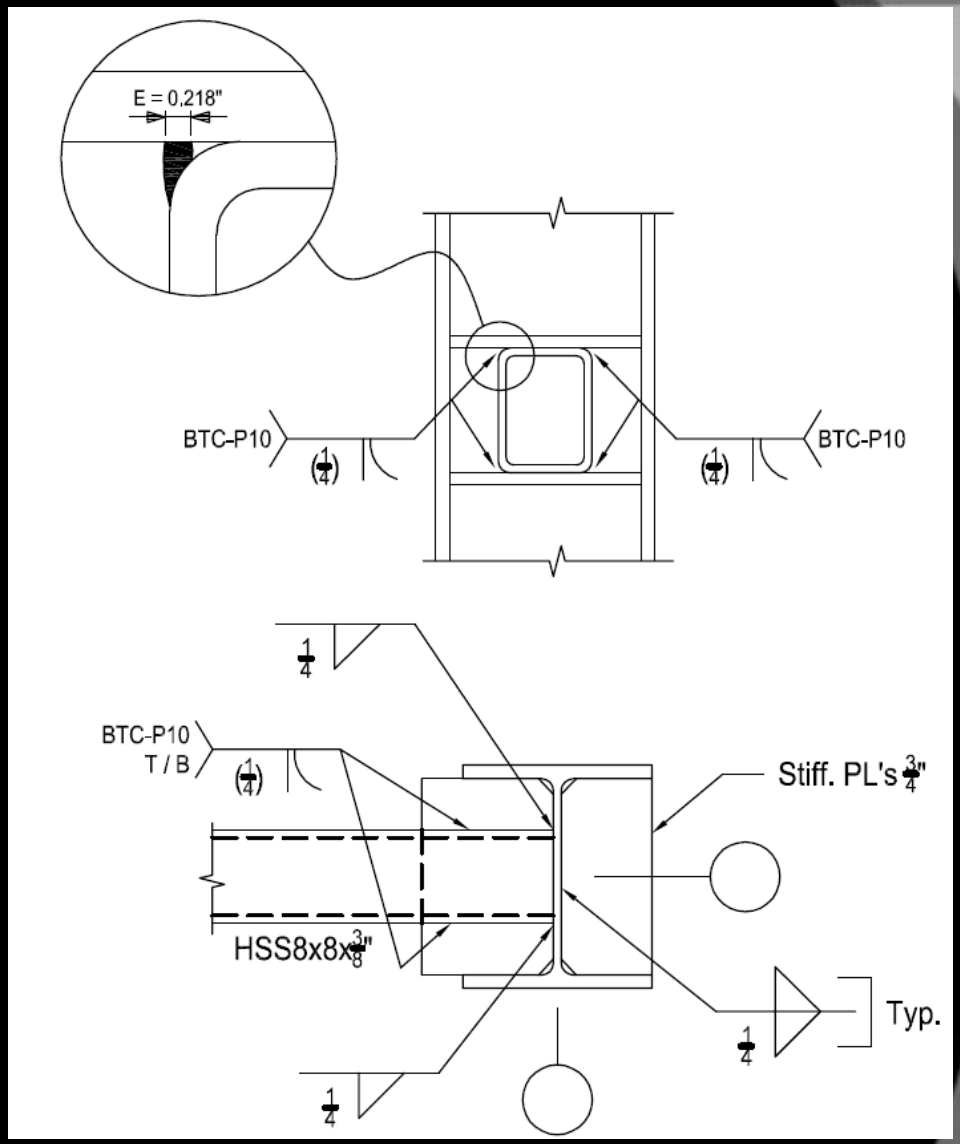
E = ¼” (Noted)



Basic Weld Types & Symbols

- BTC-P10:





Basic Weld Types & Symbols

- BTC-P10:

TABLE J2.2
Effective Weld Throats of Flare Groove Welds

Welding Process	Flare Bevel Groove[a]	Flare V-Groove
GMAW and FCAW-G	5/8 *R*	3/4 *R*
SMAW and FCAW-S	5/16 *R*	5/8 *R*
SAW	5/16 *R*	1/2 *R*

[a] For flare bevel groove with $R < 3/8$ in. (10 mm), use only reinforcing fillet weld on filled flush joint.
General note: R = radius of joint surface (can be assumed to be $2t$ for HSS), in. (mm)

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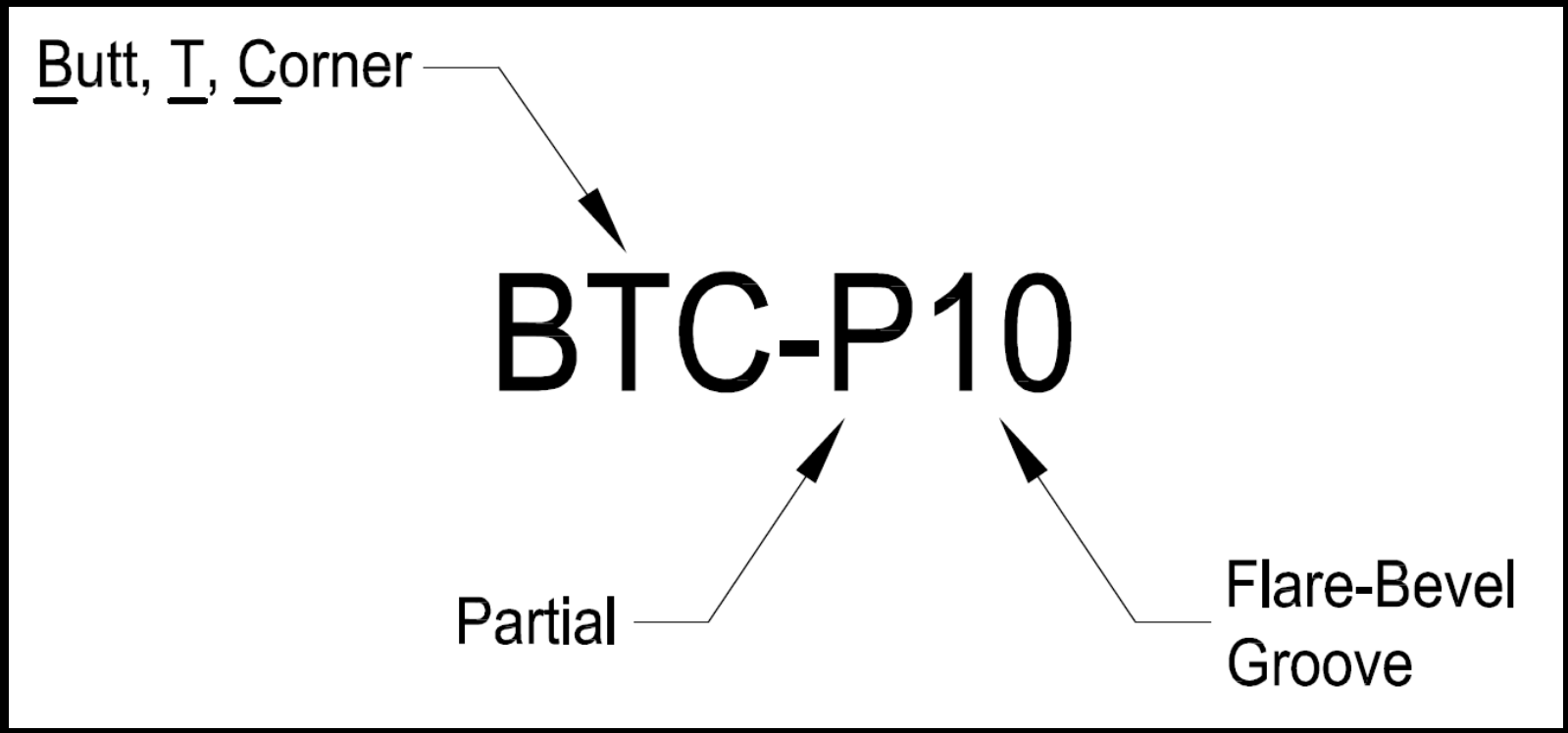
Basic Weld Types & Symbols

- BTC-P10 JOINT DESIGNATION:



Basic Weld Types & Symbols

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Be Familiar With & Always Show Process for Full or Partial Penetration Welds.

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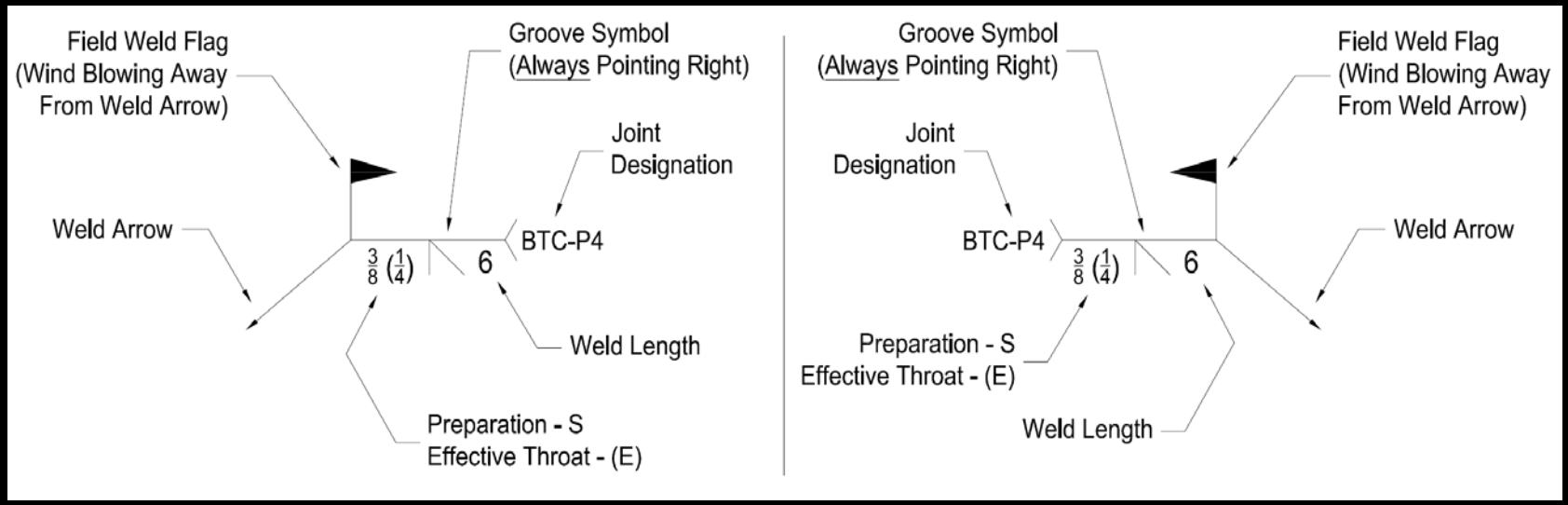
Basic Weld Types & Symbols

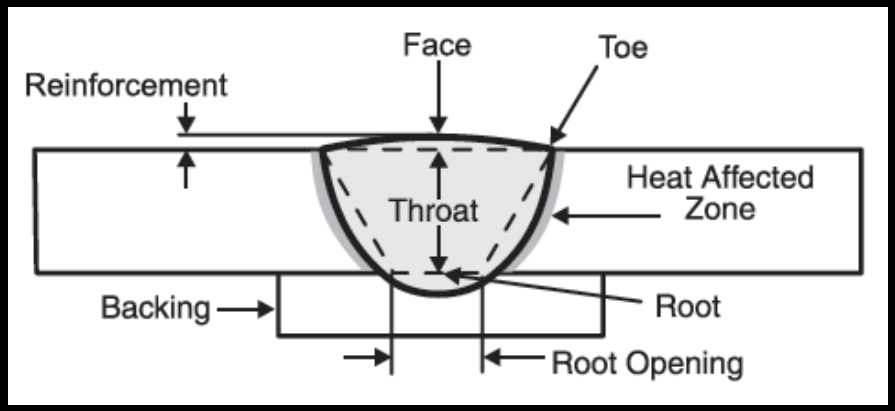
- BASIC PJP WELD SYMBOLS:

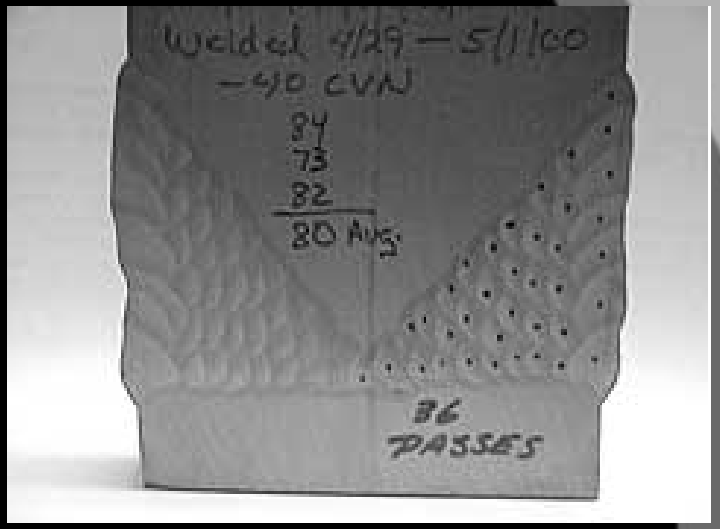


PJP WELDS

Basic Weld Types & Symbols

- FULL PENETRATION WELDS:





Strength of Joint = Strength of Lesser Material

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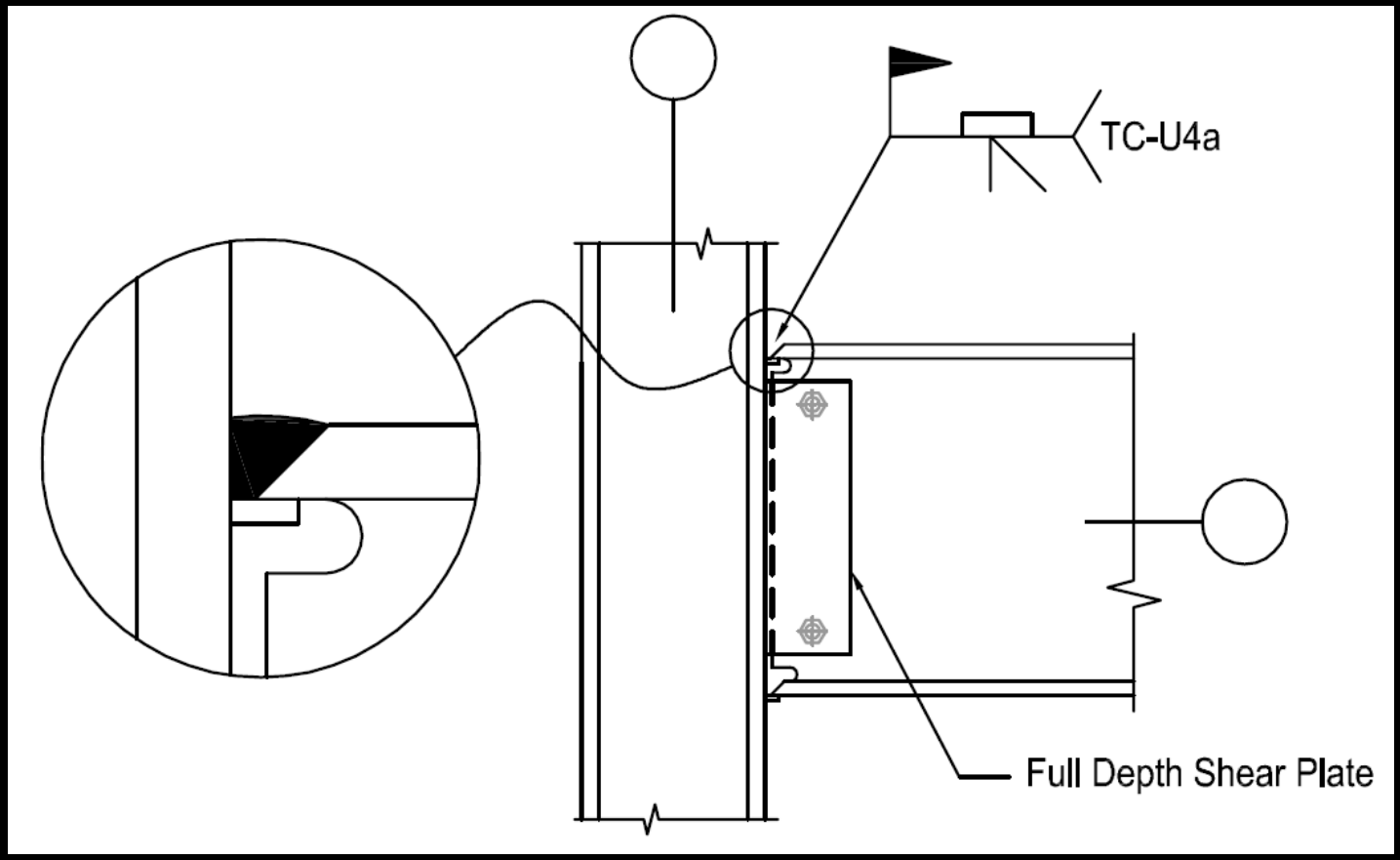
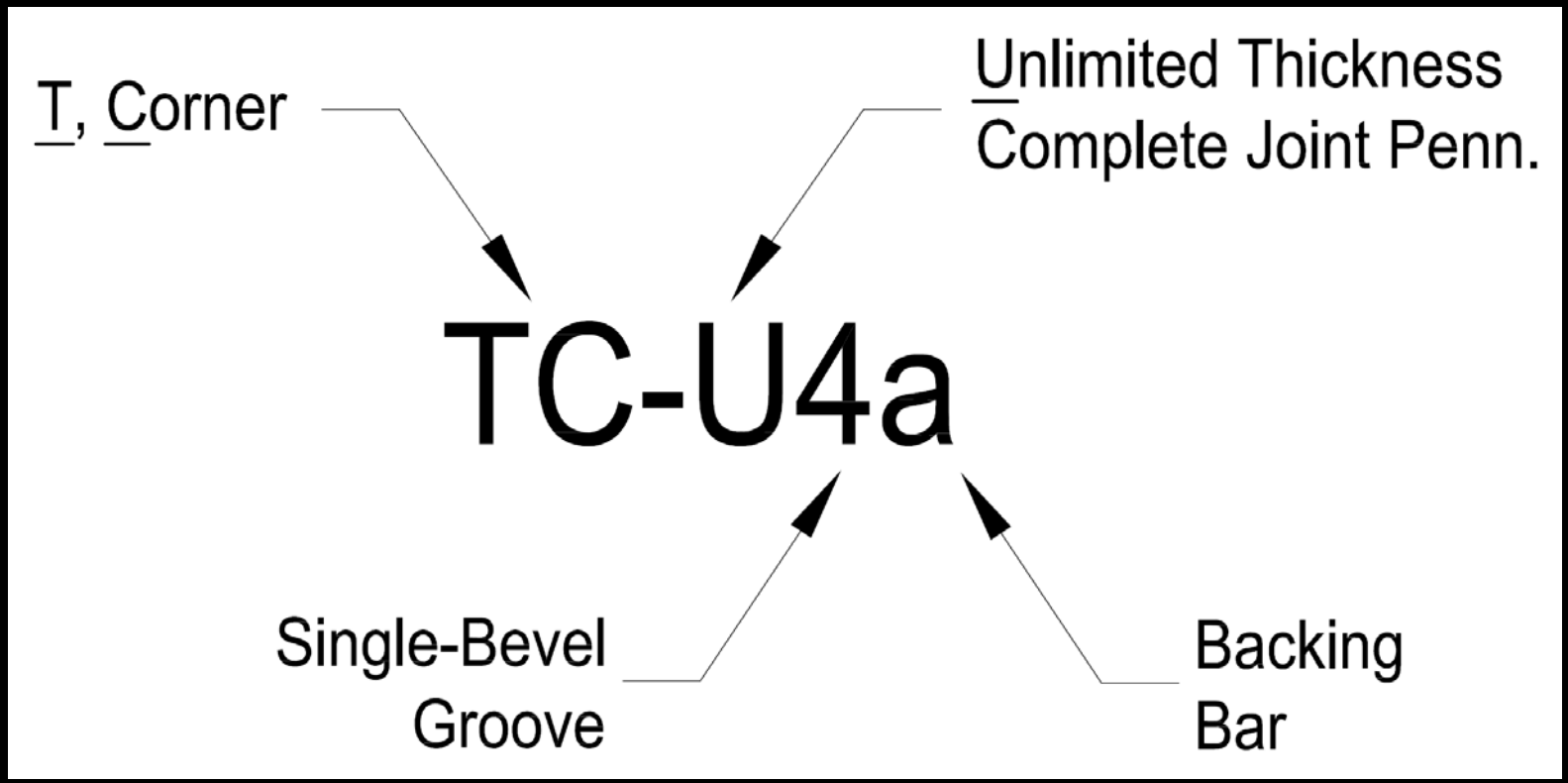
Basic Weld Types & Symbols

- TC-U4a:



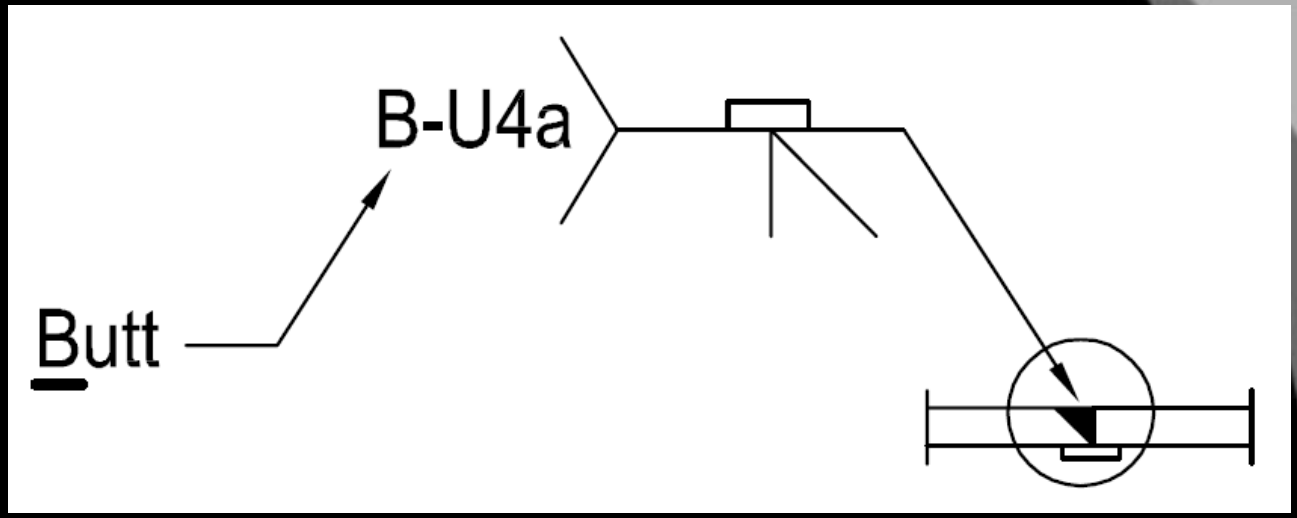
Basic Weld Types & Symbols

- TC-U4a JOINT DESIGNATION:

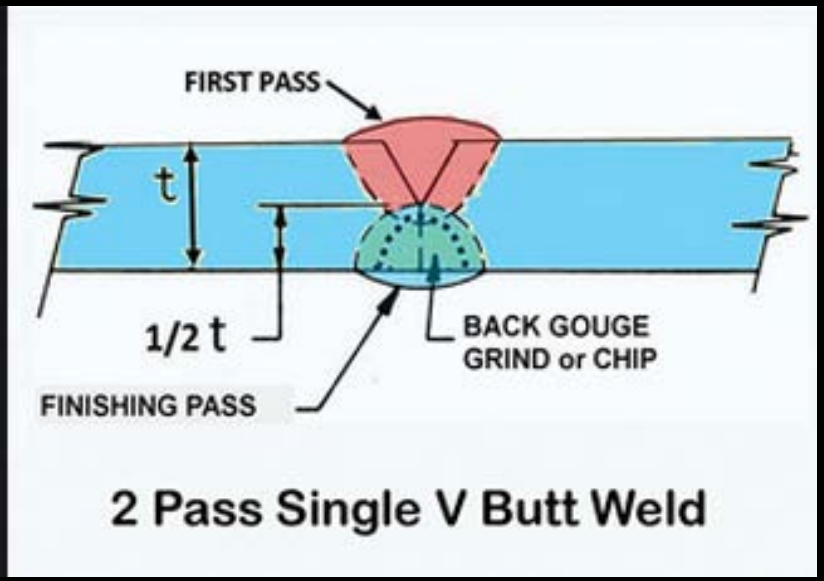


Basic Weld Types & Symbols

- BC-U4a:



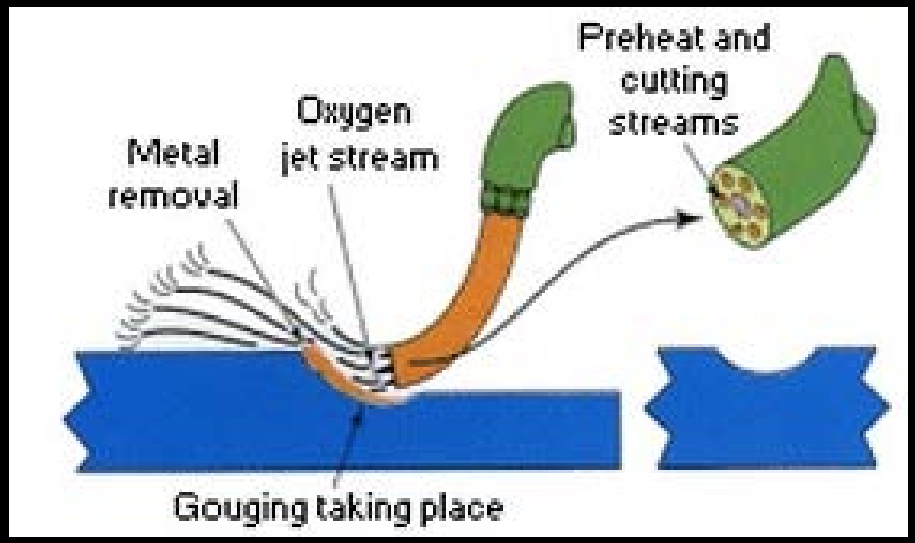
- BC-U4b:

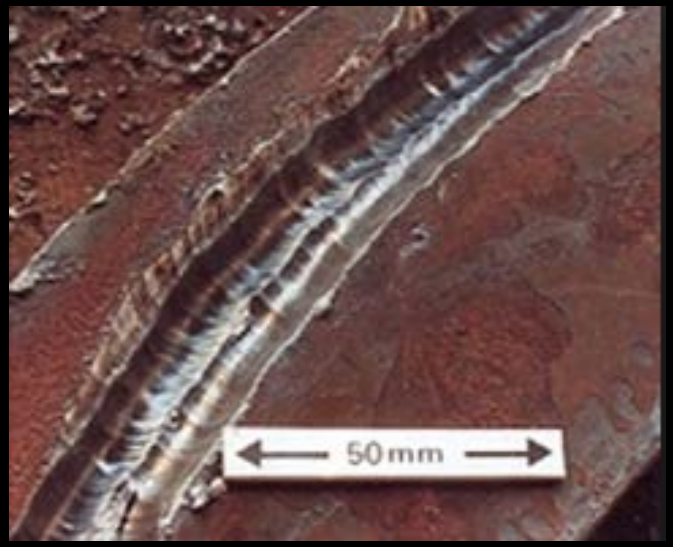


'b' for Back Gouge

Basic Weld Types & Symbols

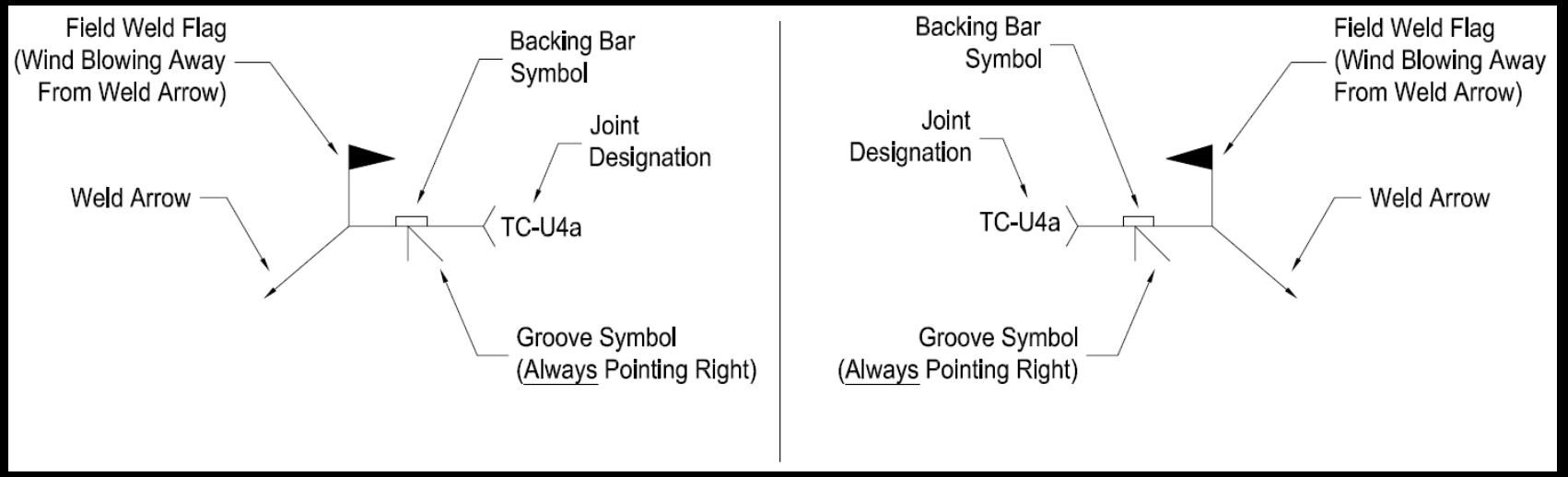
- Gouging:





Basic Weld Types & Symbols

- BASIC CJP WELD SYMBOLS:



CJP WELDS

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COMMON WELD PROCESSES & POSITIONS

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Common Weld Processes & Positions

Commonly Used Arc Welding Processes Are:

Shielded Metal Arc Welding (SMAW) – Stick Electrode

Flux Core Arc Welding (FCAW)

Gas Metal Arc Welding (GMAW)

Submerged Arc Welding (SAW)

The Type of Joint and Weld Position (Flat, Horizontal, Vertical, and Overhead) are Dependent on These Processes.

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Common Weld Processes & Positions

SMAW: (Stick- Electrode)

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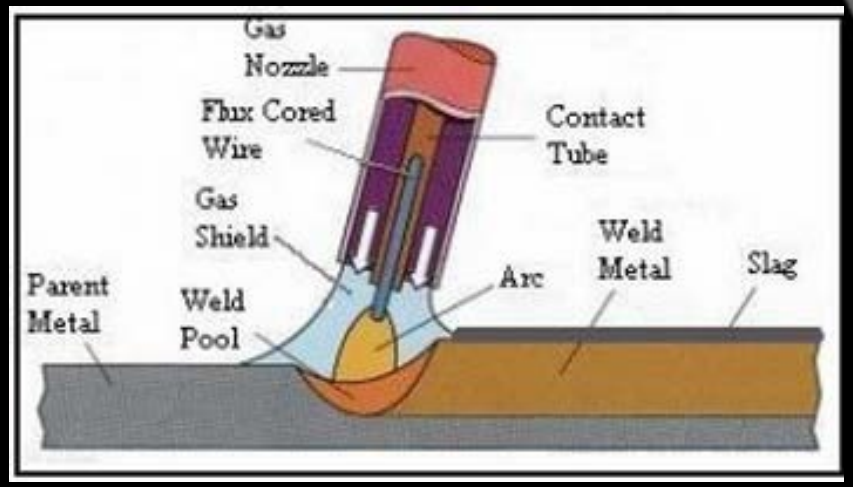
Common Weld Processes & Positions

FCAW & GMAW:



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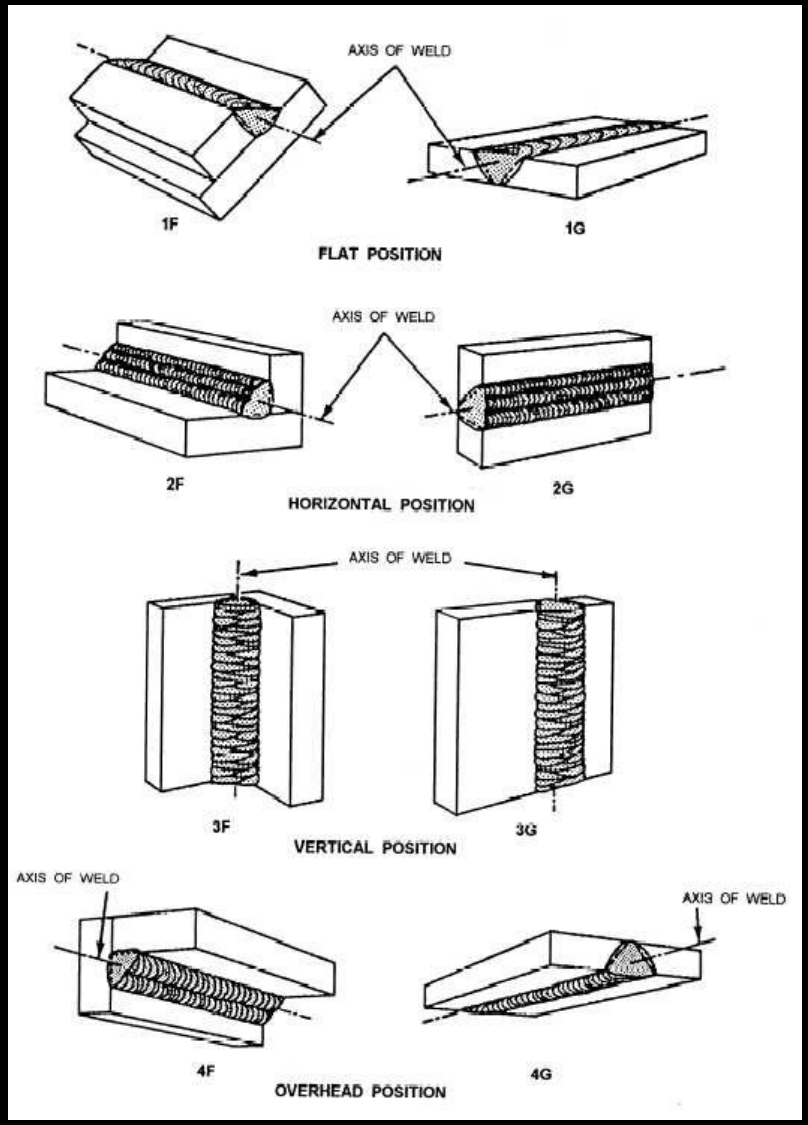
Common Weld Processes & Positions

WELD POSITIONS



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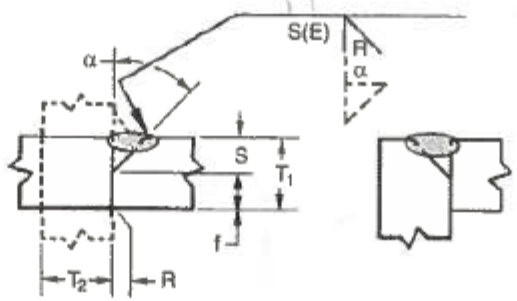
Common Weld Processes & Positions

FROM AISC / AWS D1.1:

PJP

Table 8–2 (continued)
Prequalified Welded Joints
Partial-Joint-Penetration Groove Welds

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	Total Weld Size	Notes
		T_1	T_2	Root Opening Root Face Groove Angle	Tolerances: As Detailed (see 3.12.3)	Tolerances: As Fit-Up (see 3.12.3)			
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	S–1/8	2, 5, 6, 7, 10, 11
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 V, OH	S S–1/8	1, 2, 6, 7, 10, 11
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	S	2, 6, 7, 10, 11

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BASIC WELD DESIGN

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Basic Weld Design

Fillet Weld in Shear:

ASD:

0.3(70)0.7071/16 = 0.928

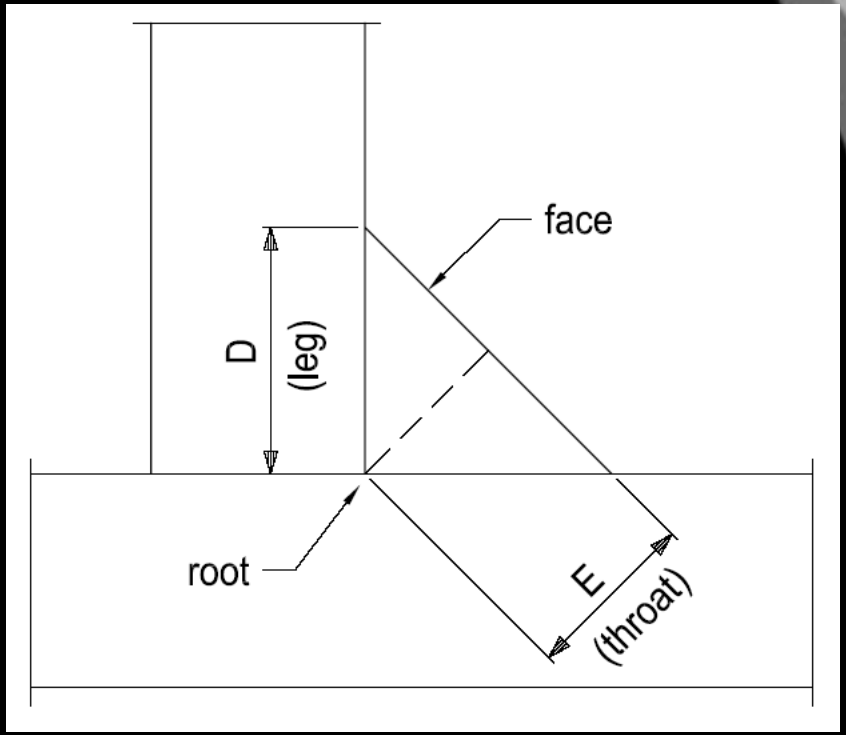
Rn/Ω = 0.928 D L

LRFD:

0.45(70)0.7071/16 = 1.392

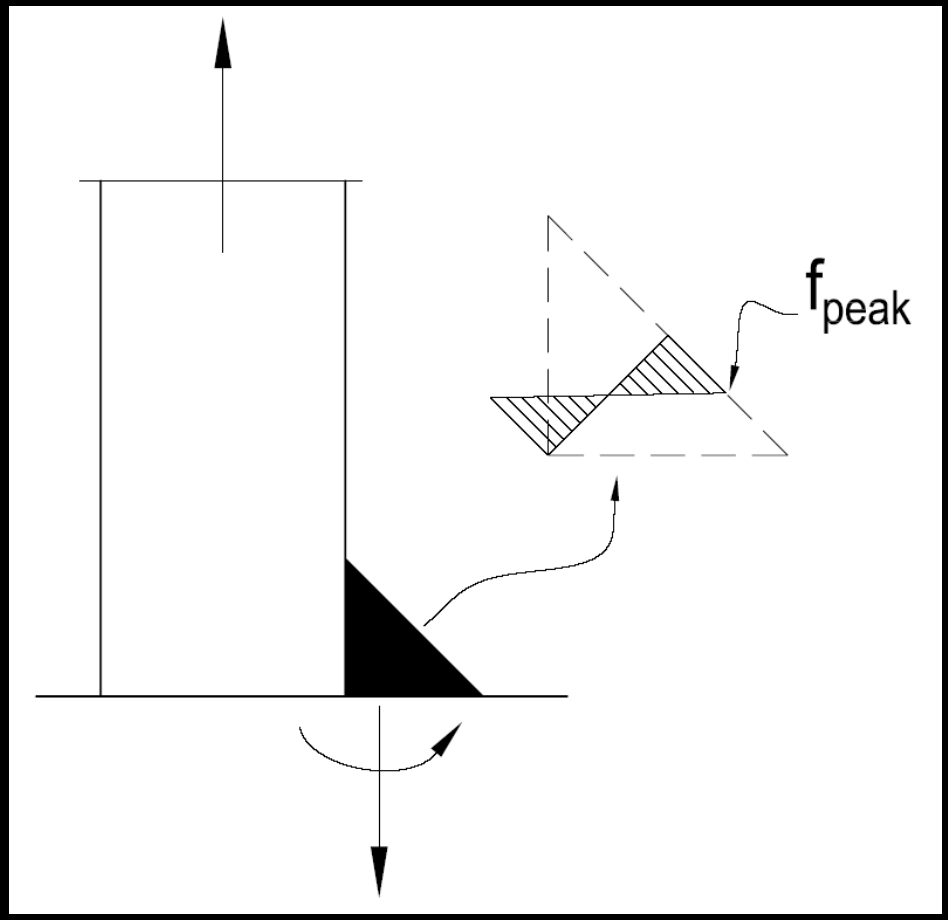
ΦRn = 1.392 D L

(E70XX Electrodes)



E = 0.7071 D

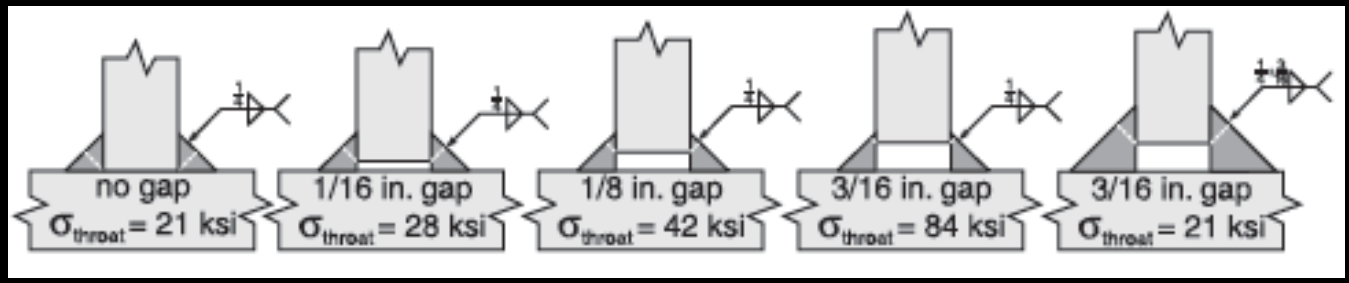
Basic Weld Design



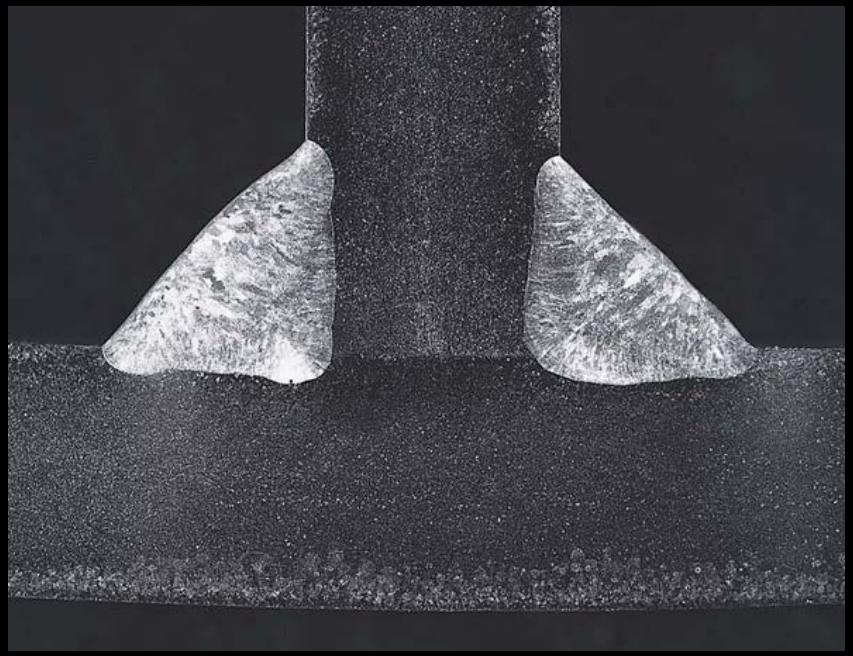
Must NEVER Put a Single Fillet Weld in Tension

Basic Weld Design

- FILLET WELDS:



Gaps in Fillet Welds are Allowed Up to 3/16”



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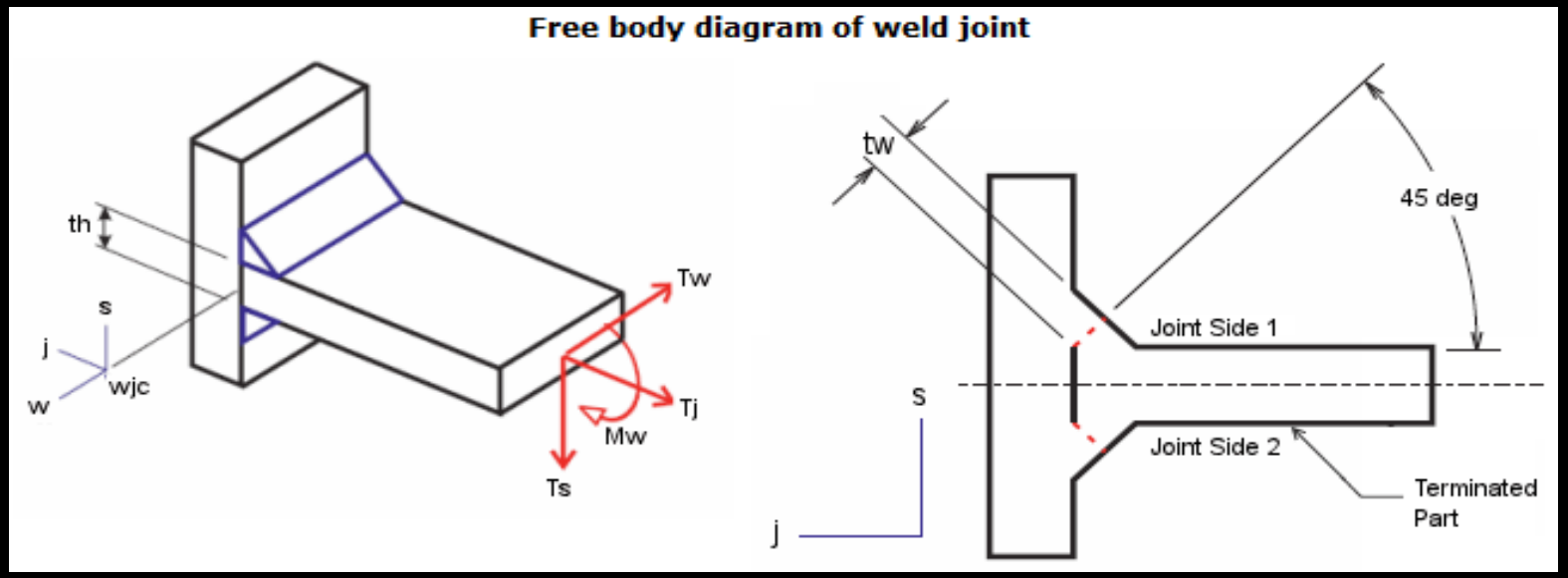
Basic Weld Design

- LOADING DOUBLE FILLET WELDS:



Must Never Load Single Fillet Weld With Moment About Longitudinal Axis – More on This Later...

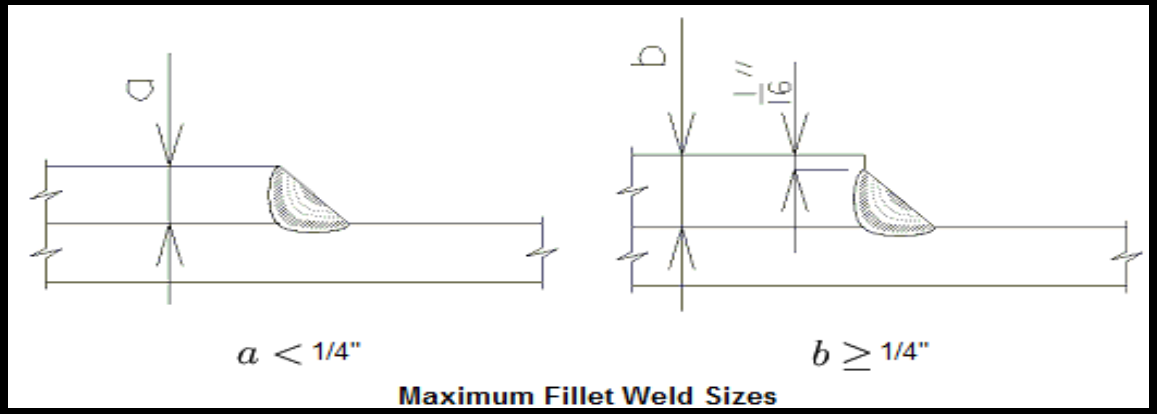
Basic Weld Design

- OVERLAPPING FILLET WELDS:

The maximum size of *fillet welds* of connected parts shall be:

(a) Along edges of material less than 1/4-in. (6 mm) thick; not greater than the thickness of the material.

(b) Along edges of material 1/4 in. (6 mm) or more in thickness; not greater than the thickness of the material minus 1/16 in. (2 mm), unless the weld is especially designated on the drawings to be built out to obtain full-throat thickness. In the as-welded condition, the distance between the edge of the base metal and the toe of the weld is permitted to be less than 1/16 in. (2 mm) provided the weld size is clearly verifiable.



Maximum Fillet Weld Sizes

May Lay 3/16” Fillet Weld on 3/16” Thk. Plate.

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Basic Weld Design

- MINIUM SIZE OF FILLET WELDS:

TABLE J2.4
Minimum Size of Fillet Welds

Material Thickness of Thinner Part Joined, in. (mm)	Minimum Size of Fillet Weld, [a] in. (mm)
To 1/4 (6) inclusive	1/8 (3)
Over 1/4 (6) to 1/2 (13)	3/16 (5)
Over 1/2 (13) to 3/4 (19)	1/4 (6)
Over 3/4 (19)	5/16 (8)

[a] Leg dimension of fillet welds. Single pass welds must be used.
Note: See Section J2.2b for maximum size of fillet welds.

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Basic Weld Design

PJP Weld in Shear:

ASD:

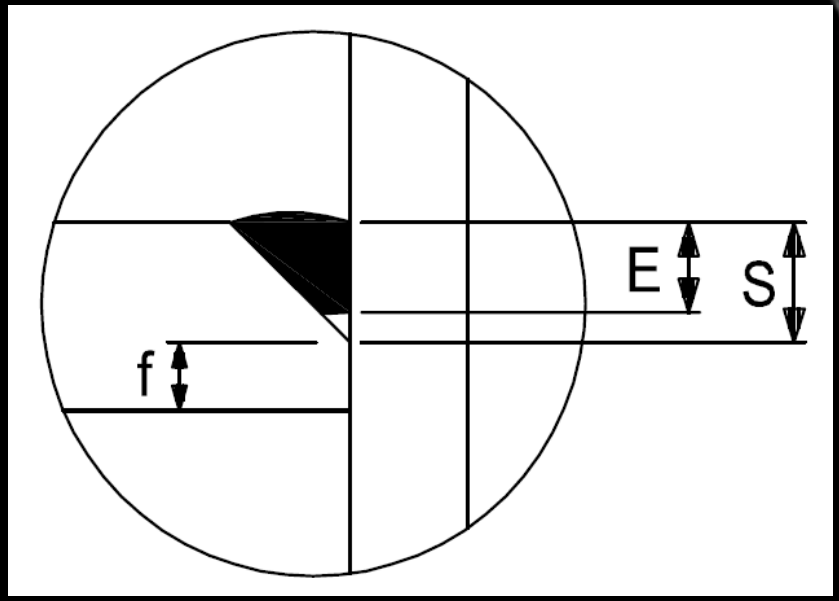
21.0 ksi (Strength)

Rn/Ω = 21.0 (E) L

LRFD:

31.5 ksi (Strength)

ΦRn = 31.5 (E) L



E = Effective Throat

S = Preparation (Bevel)

f = Root Face (Land)

R = Root Opening

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TABLE J2.5
Available Strength of Welded Joints, kips (N)

Load Type and Direction Relative to Weld Axis	Pertinent Metal	ϕ and Ω	Nominal Strength (F_{BM} or F_w) kips (N)	Effective Area (A_{BM} or A_w) in.^{2} (mm^2)	Required Filler Metal Strength Level[a][b]
COMPLETE-JOINT-PENETRATION GROOVE WELDS					
Tension Normal to weld axis	Strength of the joint is controlled by the base metal				Matching filler metal shall be used. For T and corner joints with backing left in place, notch tough filler metal is required. See Section J2.6.
Compression Normal to weld axis	Strength of the joint is controlled by the base metal				Filler metal with a strength level equal to or one strength level less than matching filler metal is permitted.
Tension or Compression Parallel to weld axis	Tension or compression in parts joined parallel to a weld need not be considered in design of welds joining the parts.				Filler metal with a strength level equal to or less than matching filler metal is permitted.
Shear	Strength of the joint is controlled by the base metal				Matching filler metal shall be used.[c]
PARTIAL-JOINT-PENETRATION GROOVE WELDS INCLUDING FLARE VEE GROOVE AND FLARE BEVEL GROOVE WELDS					
Tension Normal to weld axis	Base	$\phi = 0.90$ $\Omega = 1.67$	F_y	See J4	
	Weld	$\phi = 0.80$ $\Omega = 1.88$	$0.60F_{EXX}$	See J2.1a	
Compression Column to Base Plate and column splices designed per J1.4(a)	Compressive stress need not be considered in design of welds joining the parts.				
Compression Connections of members designed to bear other than columns as described in J1.4(b)	Base	$\phi = 0.90$ $\Omega = 1.67$	F_y	See J4	Filler metal with a strength level equal to or less than matching filler metal is permitted.
	Weld	$\phi = 0.80$ $\Omega = 1.88$	$0.60F_{EXX}$	See J2.1a	
Compression Connections not finished-to-bear	Base	$\phi = 0.90$ $\Omega = 1.67$	F_y	See J4	
	Weld	$\phi = 0.80$ $\Omega = 1.88$	$0.90F_{EXX}$	See J2.1a	
Tension or Compression Parallel to weld axis	Tension or compression in parts joined parallel to a weld need not be considered in design of welds joining the parts.				
Shear	Base	Governed by J4			
	Weld	$\phi = 0.75$ $\Omega = 2.00$	$0.60F_{EXX}$	See J2.1a	

→ 33.6 ksi IF $F_{EXX} = 70$ ksi

→ 31.5 ksi

TABLE J2.5 (cont.)
Available Strength of Welded Joints, kips (N)

Load Type and Direction Relative to Weld Axis	Pertinent Metal	ϕ and Ω	Nominal Strength (F_{BM} or F_w) kips (N)	Effective Area (A_{BM} or A_w) in.^{2} (mm^2)	Required Filler Metal Strength Level[a][b]
FILLET WELDS INCLUDING FILLETS IN HOLES AND SLOTS AND SKEWED T-JOINTS					
Shear	Base	Governed by J4			Filler metal with a strength level equal to or less than matching filler metal is permitted.
	Weld	$\phi = 0.75$ $\Omega = 2.00$	$0.60F_{EXX}$[d]	See J2.2a	
Tension or Compression Parallel to weld axis	Tension or compression in parts joined parallel to a weld need not be considered in design of welds joining the parts.				
PLUG AND SLOT WELDS					
Shear Parallel to faying surface on the effective area	Base	Governed by J4			Filler metal with a strength level equal to or less than matching filler metal is permitted.
	Weld	$\phi = 0.75$ $\Omega = 2.00$	$0.60F_{EXX}$	J2.3a	

[a] For matching weld metal see AWS D1.1, Section 3.3.
[b] Filler metal with a strength level one strength level greater than matching is permitted.
[c] Filler metals with a strength level less than matching may be used for groove welds between the webs and flanges of built-up sections transferring shear loads, or in applications where high restraint is a concern. In these applications, the weld joint shall be detailed and the weld shall be designed using the thickness of the material as the effective throat, $\phi = 0.80$, $\Omega = 1.88$ and $0.60F_{EXX}$ as the nominal strength.
[d] Alternatively, the provisions of J2.4(a) are permitted provided the deformation compatibility of the various weld elements is considered. Alternatively, Sections J2.4(b) and (c) are special applications of J2.4(a) that provide for deformation compatibility.

Alternatively, for *fillet welds* loaded in-plane the *design strength*, ϕR_n and the *allowable strength*, R_n/Ω, of welds is permitted to be determined as follows:

$$\phi = 0.75 \text{ (LRFD)} \qquad \Omega = 2.00 \text{ (ASD)}$$

(a) For a linear weld group loaded in-plane through the center of gravity

$$R_n = F_w A_w \tag{J2-4}$$

where

$$F_w = 0.60F_{EXX}\left(1.0 + 0.50\sin^{1.5}\theta\right) \tag{J2-5}$$

and

F_{EXX} = electrode classification number, ksi (MPa)
θ = angle of loading measured from the weld longitudinal axis, degrees
A_w = effective area of the weld, in.^{2} (mm^2)

User Note: A linear weld group is one in which all elements are in a line or are parallel.

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Basic Weld Design

TWO METHODS:

- ELASTIC METHOD

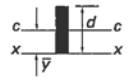
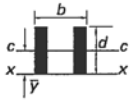
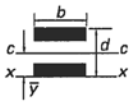
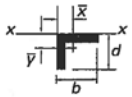
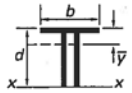
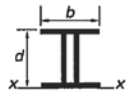
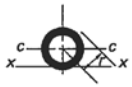
- INSTANTANEOUS CENTER OF ROTATION, IC, METHOD

LBYD

Elastic Method

Properties of Weld Groups

If you are using this table you are doing ELASTIC method.

weld configuration	centroid location	section modulus $S = I_{c,x}/\bar{y}$	polar moment of inertia $J = I_{c,x} + I_{c,y}$
	$\bar{y} = \frac{d}{2}$	$\frac{d^2}{6}$	$\frac{d^3}{12}$
	$\bar{y} = \frac{d}{2}$	$\frac{d^2}{3}$	$\frac{d(3b^2 + d^2)}{6}$
	$\bar{y} = \frac{d}{2}$	bd	$\frac{b(3d^2 + b^2)}{6}$
	$\bar{y} = \frac{d^2}{2(b+d)}$ $\bar{x} = \frac{b^2}{2(b+d)}$	$\frac{4bd + d^2}{6}$	$\frac{(b+d)^4 - 6b^2d^2}{12(b+d)}$
	$\bar{x} = \frac{b^2}{2b + d}$	$bd + \frac{d^2}{6}$	$\frac{8b^3 + 6bd^2 + d^3}{12} - \frac{b^4}{2b + d}$
	$\bar{y} = \frac{d^2}{b + 2d}$	$\frac{2bd + d^2}{3}$	$\frac{b^3 + 6b^2d + 8d^3}{12} - \frac{d^4}{2d + b}$
	$\bar{y} = \frac{d}{2}$	$bd + \frac{d^2}{3}$	$\frac{(b+d)^3}{6}$
	$\bar{y} = \frac{d^2}{b + 2d}$	$\frac{2bd + d^2}{3}$	$\frac{b^3 + 8d^3}{12} - \frac{d^4}{b + 2d}$
	$\bar{y} = \frac{d}{2}$	$bd + \frac{d^2}{3}$	$\frac{b^3 + 3bd^2 + d^3}{6}$
	$\bar{y} = r$	πr^2	$2\pi r^3$

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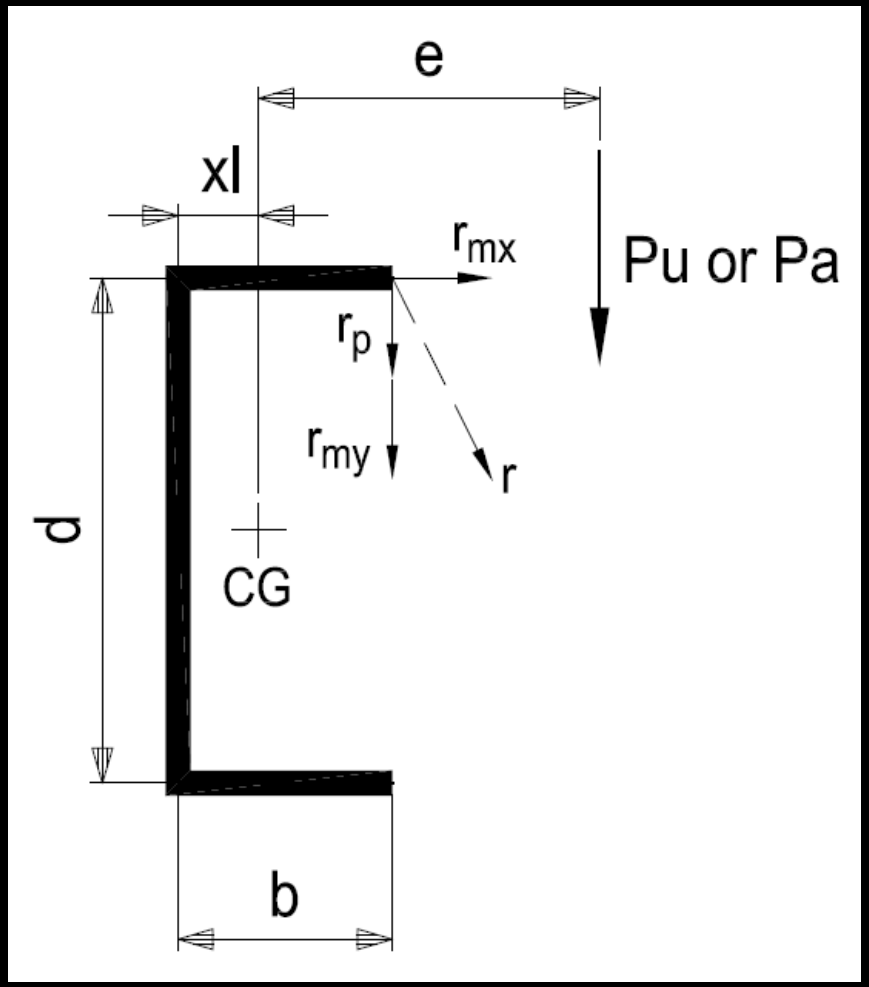
Elastic Method



- Eccentric Force is Resolved Into a Shear & Moment Acting at the Center of Gravity (CG) of the Bolt Group.

- r_p : All Weld Elements Share P ‘Equally’.

- r_{mx} , r_{my} : Proportional to Distance from CG.

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Instantaneous Center of Rotation (IC Method)

Properties of Weld Groups

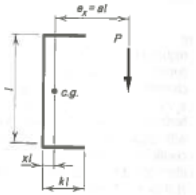
If you are using this table you are doing <u>Instantaneous Center of Rotation</u> method.

Table 8–8
Coefficients *C*
for Eccentrically Loaded Weld Groups
Angle = 0°

Available Strength of a weld group, ϕR_n or R_n/Ω, is determined with
$R_n = CC_1Dl$ ($\phi = 0.75$, $\Omega = 2.00$)
or

LRFD	ASD
$C_{min} = \frac{P_u}{\phi C_1 Dl}$ $D_{min} = \frac{P_u}{\phi C C_1 l}$ $l_{min} = \frac{\Omega P_u}{\phi C C_1 D}$	$C_{min} = \frac{\Omega P_a}{C_1 Dl}$ $D_{min} = \frac{\Omega P_a}{C C_1 l}$ $l_{min} = \frac{\Omega P_a}{C C_1 D}$

where
P = required force, P_u or P_a, kips
D = number of sixteenths-of-an-inch in the fillet weld size
l = characteristic length of weld group, in.
$a = e_x / l$
e_x = horizontal component of eccentricity of P with respect to centroid of weld group, in.
C = coefficient tabulated below
C_1 = electrode strength coefficient from Table 8-4 (1.0 for E70XX electrodes)



	k														
a	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8
0.00	1.53	2.09	2.64	3.20	3.76	4.32	4.87	5.43	5.99	6.54	7.10	8.21	9.33	10.4	11.6
0.100	1.86	2.28	2.78	3.30	3.84	4.37	4.92	5.46	6.01	6.56	7.11	8.21	9.32	10.4	11.5
0.150	1.83	2.25	2.73	3.23	3.75	4.27	4.80	5.33	5.87	6.40	6.94	8.02	9.12	10.2	11.3
0.200	1.76	2.18	2.63	3.11	3.60	4.10	4.61	5.13	5.64	6.16	6.68	7.73	8.78	9.83	10.9
0.250	1.66	2.07	2.51	2.96	3.42	3.90	4.38	4.87	5.37	5.86	6.36	7.37	8.39	9.42	10.5
0.300	1.55	1.95	2.36	2.79	3.23	3.68	4.14	4.60	5.07	5.55	6.03	7.01	8.00	9.00	10.0
0.400	1.33	1.69	2.07	2.45	2.84	3.24	3.65	4.07	4.50	4.94	5.39	6.30	7.24	8.19	9.16
0.500	1.15	1.46	1.79	2.14	2.49	2.85	3.22	3.60	4.00	4.40	4.81	5.67	6.56	7.47	8.40
0.600	0.997	1.27	1.57	1.88	2.19	2.52	2.85	3.20	3.56	3.94	4.32	5.13	5.97	6.84	7.73
0.700	0.879	1.12	1.38	1.66	1.95	2.24	2.55	2.87	3.20	3.55	3.91	4.66	5.46	6.29	7.15
0.800	0.781	0.995	1.23	1.48	1.75	2.02	2.30	2.59	2.90	3.22	3.56	4.27	5.02	5.81	6.64
0.900	0.703	0.895	1.11	1.33	1.58	1.83	2.09	2.36	2.64	2.94	3.26	3.93	4.64	5.40	6.18
1.00	0.637	0.812	1.00	1.21	1.44	1.67	1.91	2.16	2.43	2.71	3.01	3.63	4.31	5.02	5.77
1.20	0.537	0.683	0.844	1.02	1.21	1.42	1.63	1.85	2.08	2.33	2.59	3.15	3.75	4.39	5.07
1.40	0.464	0.588	0.728	0.881	1.05	1.23	1.41	1.61	1.82	2.04	2.27	2.77	3.31	3.89	4.50
1.60	0.407	0.516	0.639	0.775	0.923	1.08	1.25	1.43	1.61	1.81	2.02	2.46	2.95	3.47	4.04
1.80	0.363	0.460	0.569	0.691	0.824	0.969	1.12	1.28	1.45	1.62	1.81	2.22	2.66	3.14	3.65
2.00	0.327	0.415	0.513	0.623	0.744	0.876	1.01	1.16	1.31	1.47	1.64	2.01	2.42	2.86	3.33
2.20	0.297	0.377	0.467	0.567	0.677	0.799	0.925	1.06	1.20	1.35	1.50	1.84	2.21	2.62	3.07
2.40	0.273	0.347	0.428	0.520	0.623	0.735	0.852	0.972	1.10	1.24	1.38	1.70	2.04	2.42	2.83
2.60	0.252	0.320	0.396	0.480	0.575	0.679	0.788	0.900	1.02	1.15	1.28	1.57	1.90	2.25	2.63
2.80	0.235	0.297	0.368	0.447	0.535	0.632	0.733	0.837	0.949	1.07	1.19	1.47	1.77	2.10	2.46
3.00	0.219	0.277	0.343	0.417	0.500	0.591	0.685	0.784	0.888	0.999	1.12	1.37	1.65	1.97	2.31

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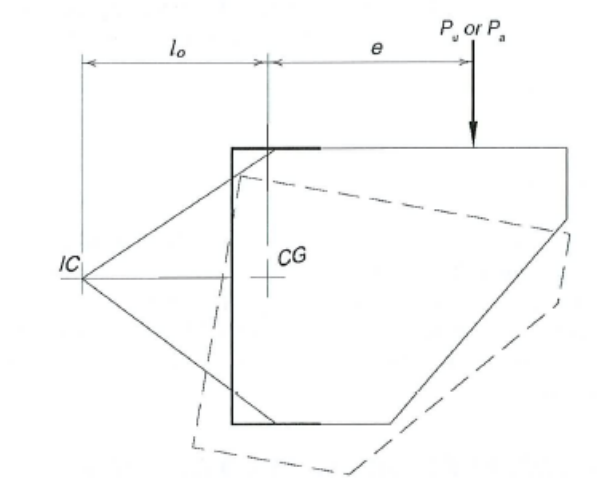
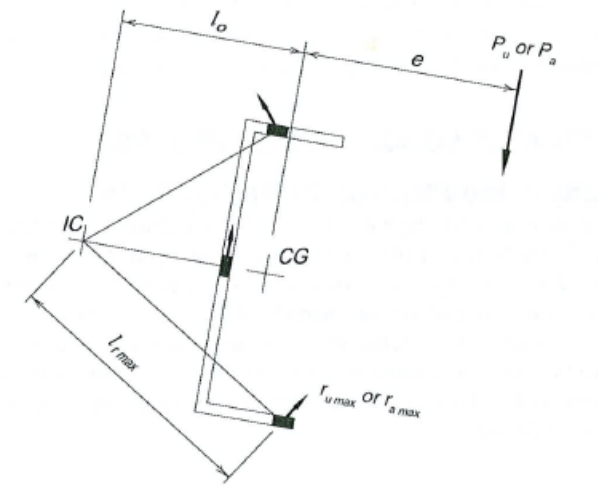
Instantaneous Center of Rotation (IC Method)



(a) Instantaneous center of rotation (IC)



(b) Forces on weld elements

- Eccentricity Produces Both a Relative Rotation & Translation

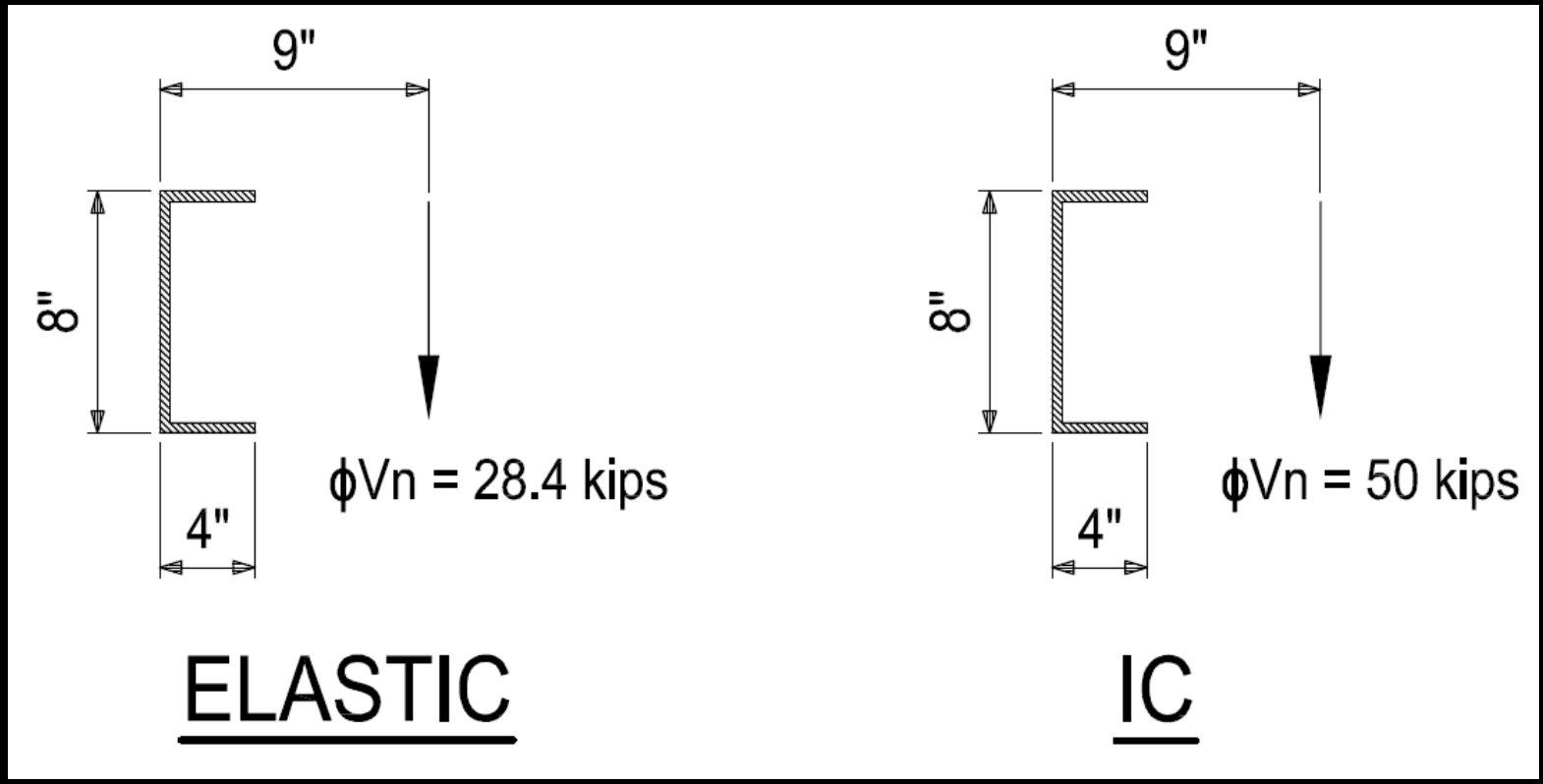
- The Combined Effect of This Relative Movement is Equivalent to a Rotation About IC.

- Location of IC Depends on Weld Geometry.

LBYD

Basic Weld Design

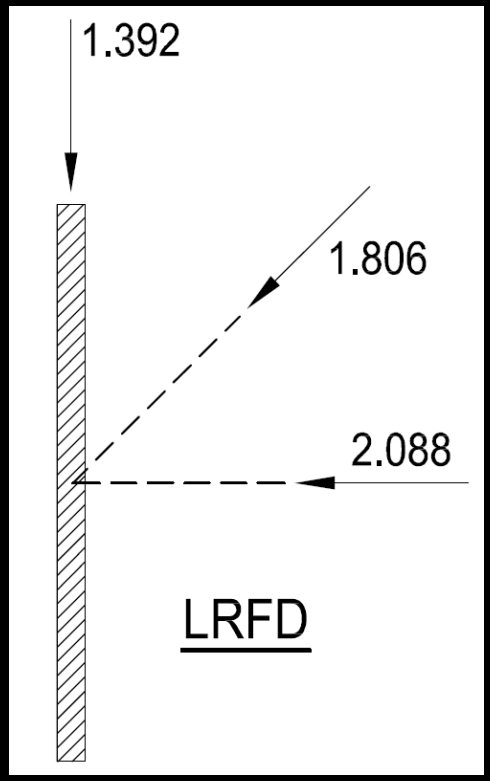
COMPARISON OF TWO METHODS:

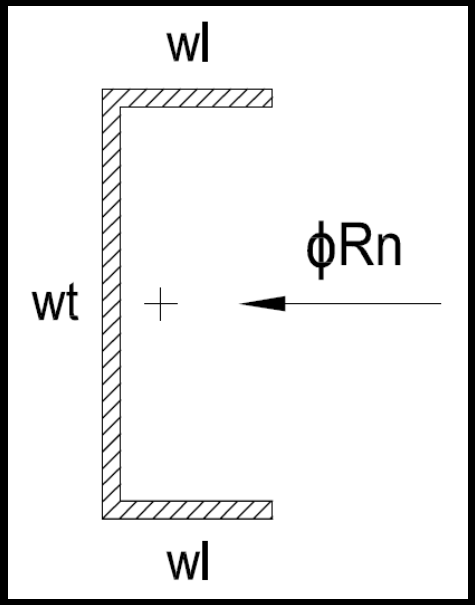


D = 5/16”

Basic Weld Design

TRANVERSELY LOADED FILLET WELDS:





$$F_{nw} = 0.60 F_{EXX}\left(1.0 + 0.50 \sin^{1.5} \theta\right)$$

$$R_n = R_{nwl} + R_{nwt}$$

$$R_n = 0.85\ R_{nwl} + 1.5\ R_{nwt}$$

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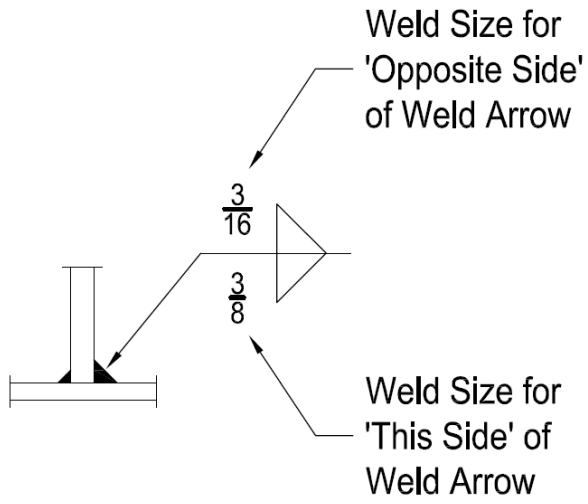
CORRECT WELD SYMBOLS & PLACEMENT

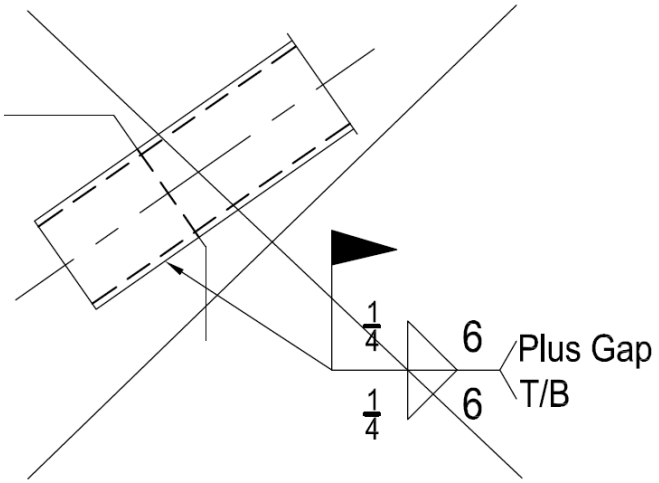
LBYD

Correct Weld Symbols & Placement

- ERRONEOUS WELD SYMBOLS:



Double Fillet Weld Symbol Signifies
Weld on Both Sides of PLATE



NOT on Both Sides of Element
(e.g. HSS Brace)

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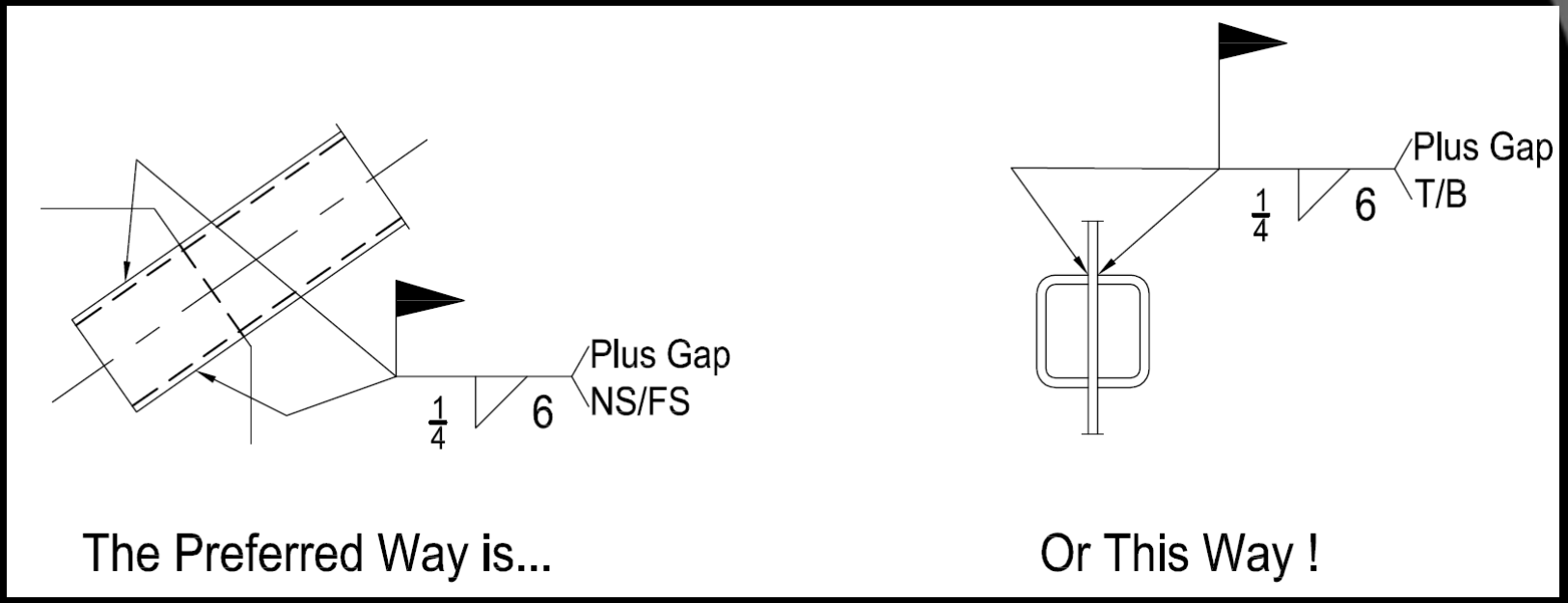
Correct Weld Symbols & Placement

- ERRONEOUS WELD SYMBOLS:



TIP: 'PLUS GAP' OR 'INCREASE FOR GAP' MEANS THAT THE WELD SIZE MUST BE INCREASED FOR THE AMOUNT OF GAP BETWEEN THE SLOT IN THE HSS AND THE GUSSET PLATE – IF GAP IS 1/16" INCREASE 1/4" to 5/16".

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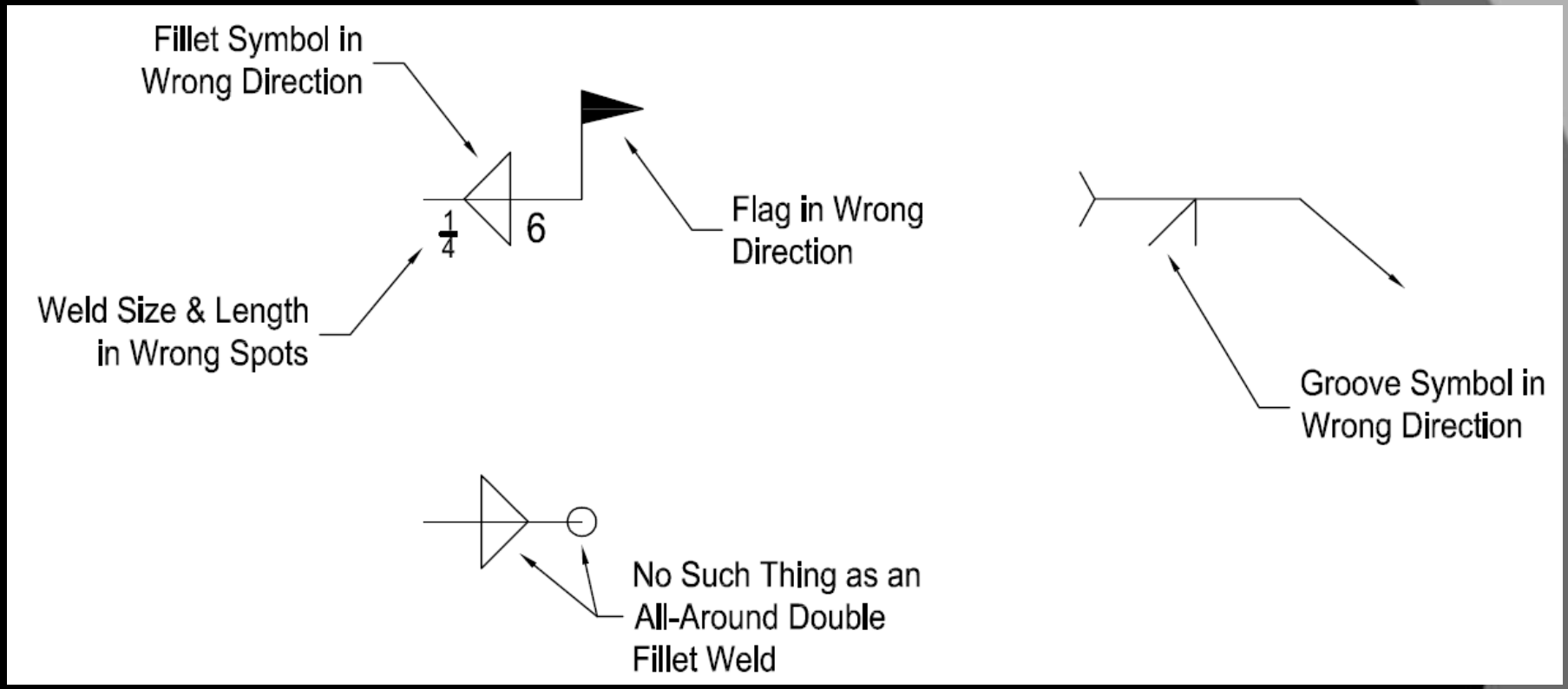
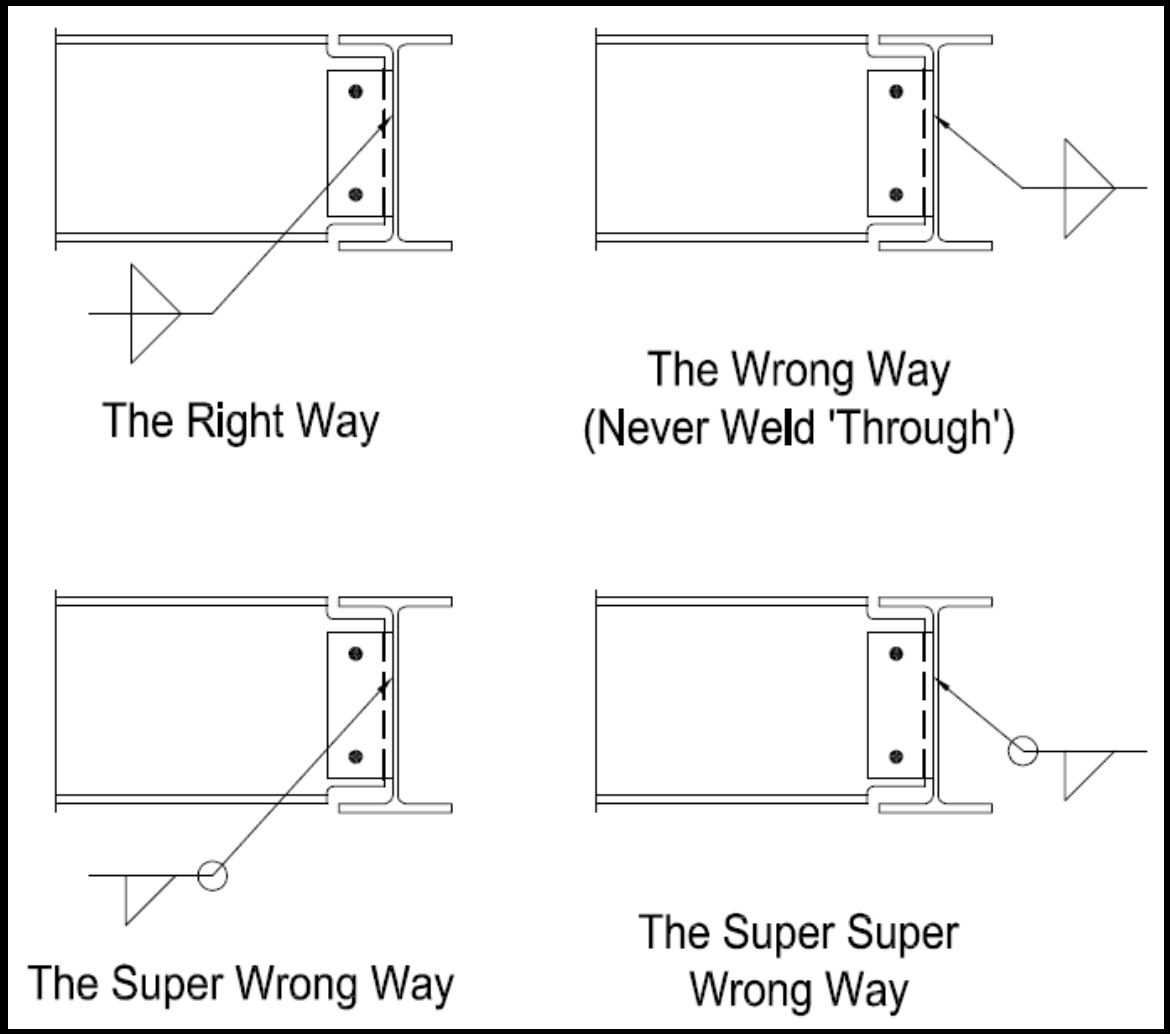
Correct Weld Symbols & Placement

- ERRONEOUS WELD SYMBOLS:



Correct Weld Symbols & Placement

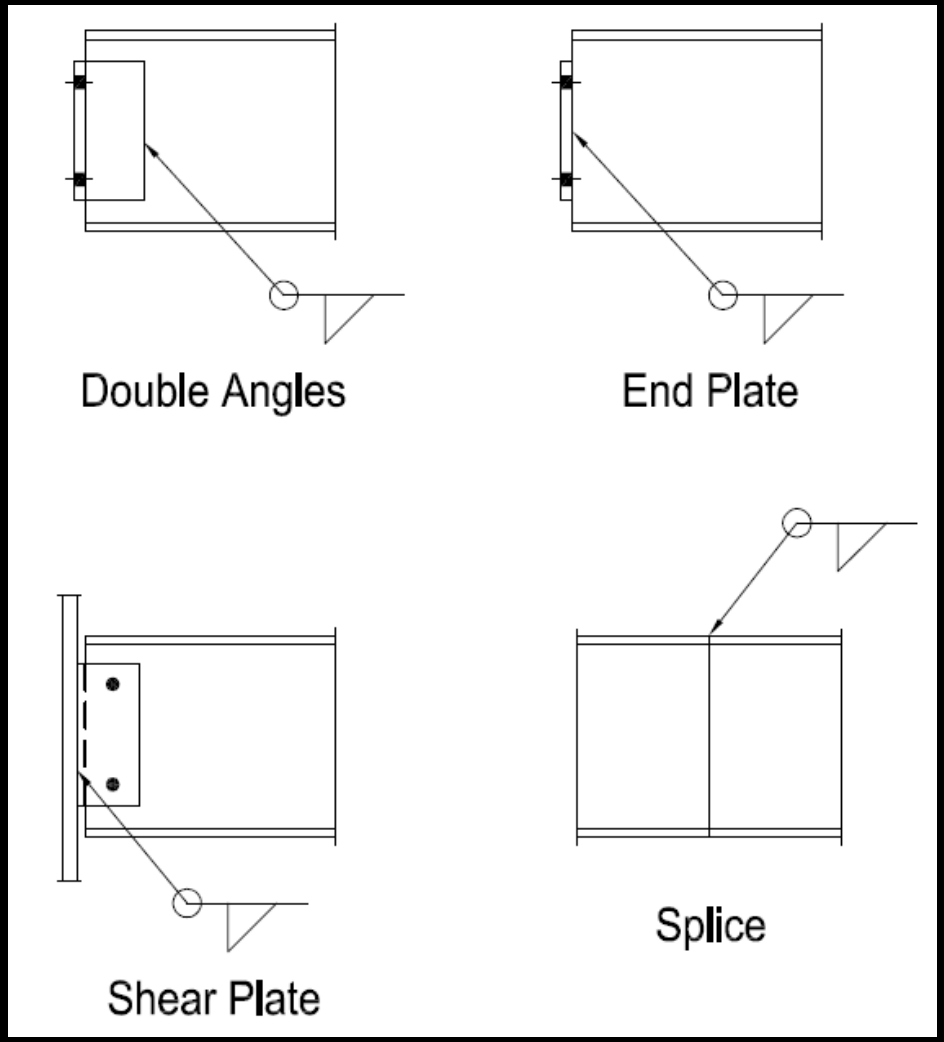
- ERRONEOUS WELD SYMBOLS:



Correct Weld Symbols & Placement

- ERRONEOUS WELD SYMBOLS:

Overuse of All-Around Weld Symbol:



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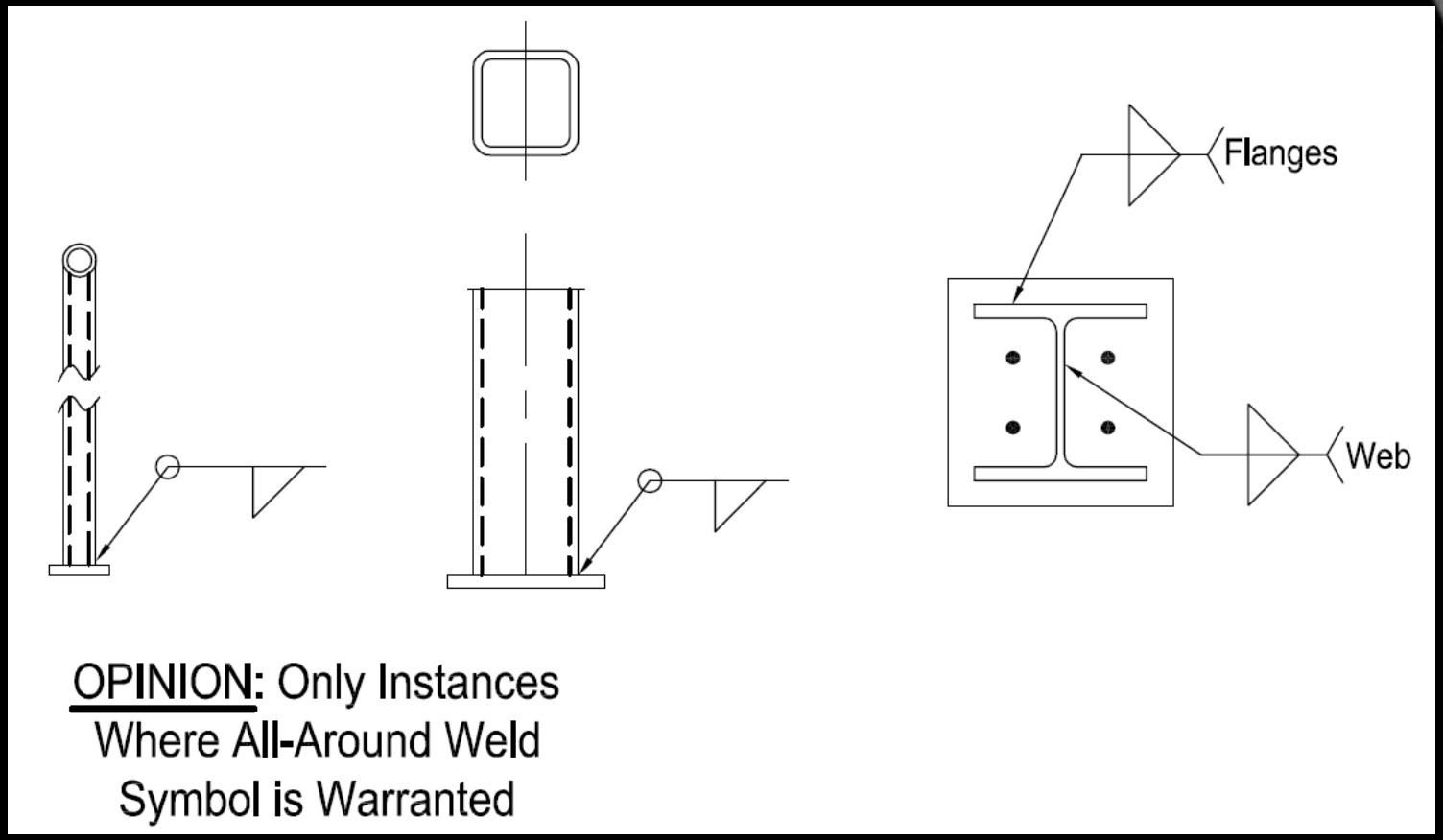
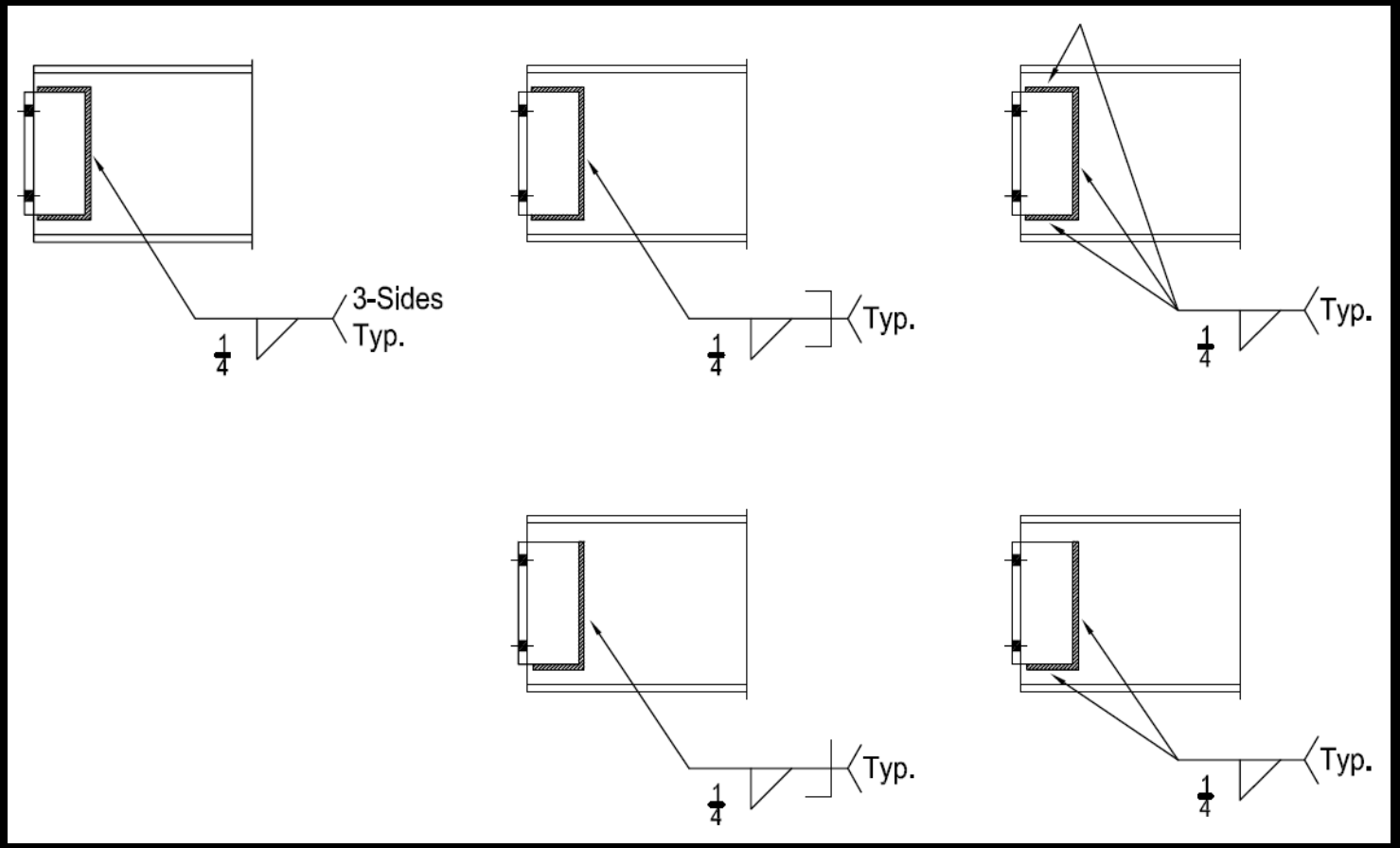
Correct Weld Symbols & Placement

- ALL-AROUND WELD SYMBOL:



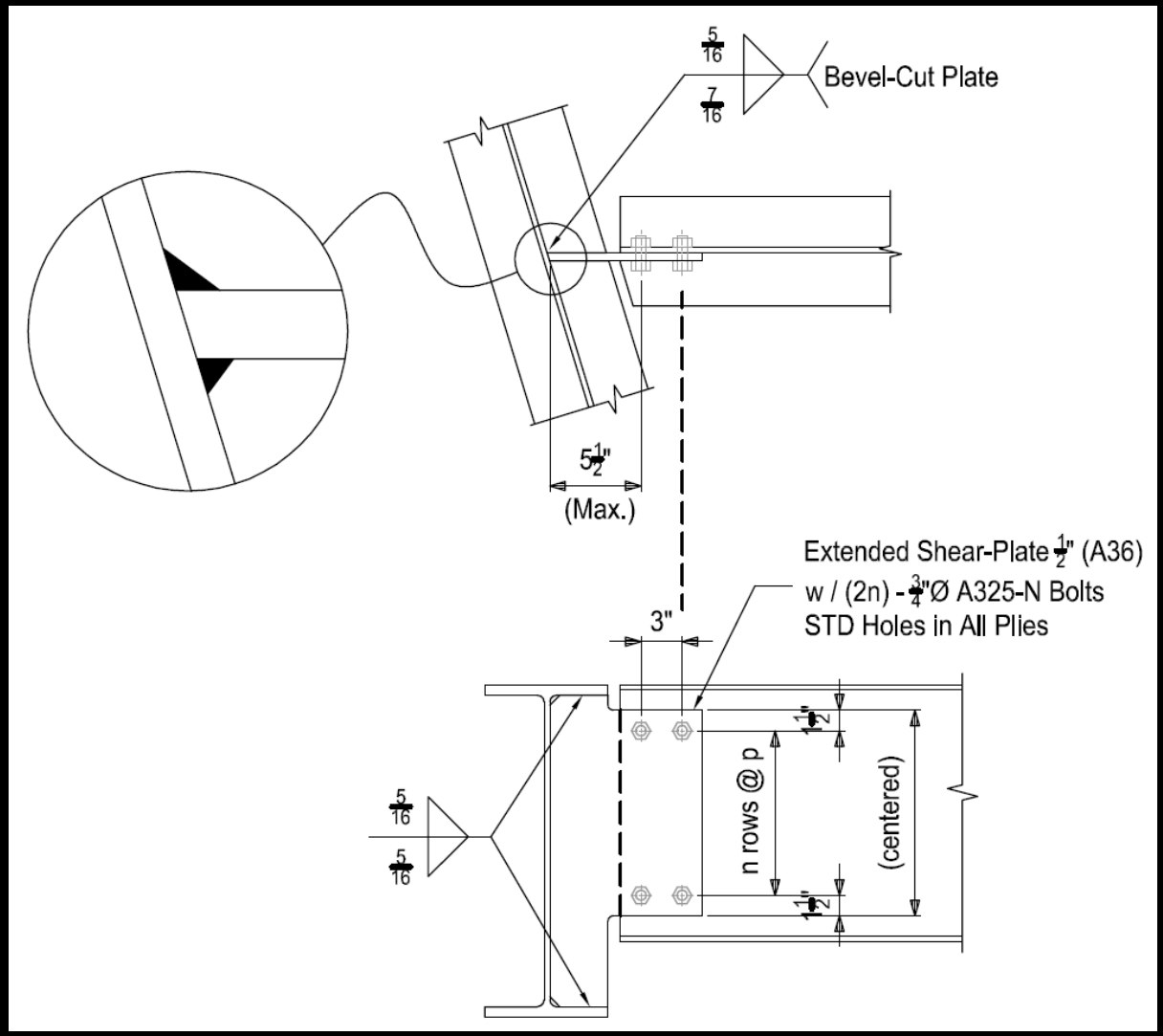
Correct Weld Symbols & Placement

- ‘C’ SHAPED & ‘L’ SHAPED WELDS:



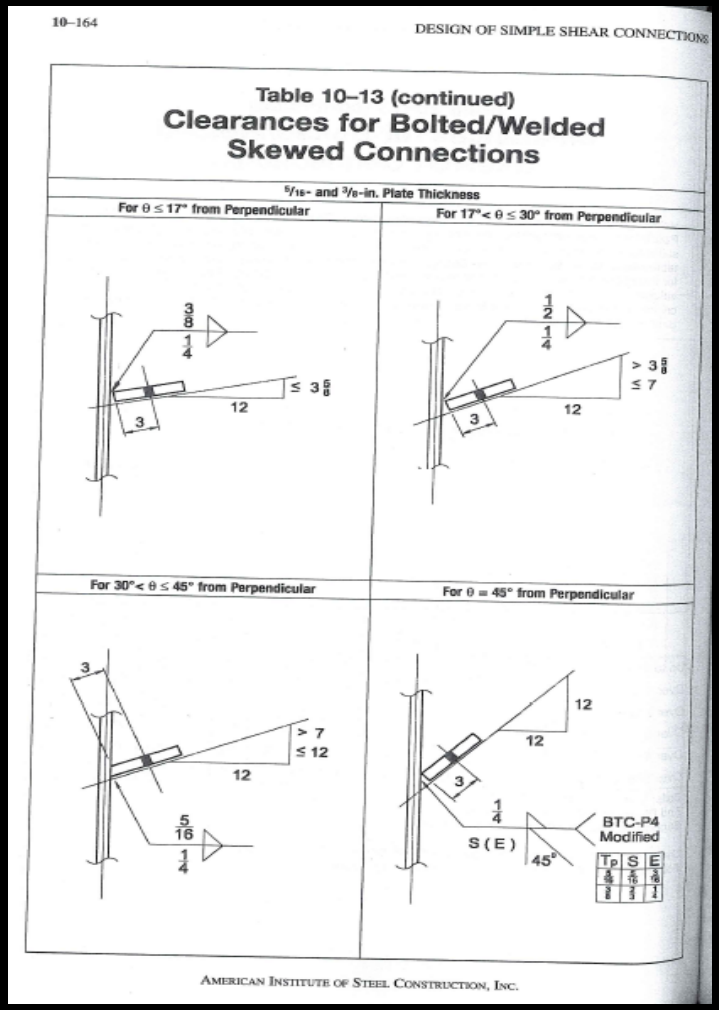
Correct Weld Symbols & Placement

- EXTENDED SHEAR PLATE WELDING:



Correct Weld Symbols & Placement

- SKEWED WELDS:



10–164 DESIGN OF SIMPLE SHEAR CONNECTIONS

Table 10–13 (continued)
Clearances for Bolted/Welded Skewed Connections

5/16- and 3/8-in. Plate Thickness

For θ ≤ 17° from Perpendicular	For 17° < θ ≤ 30° from Perpendicular
For 30° < θ ≤ 45° from Perpendicular	For θ = 45° from Perpendicular

BTC-P4 Modified

Tp	S	E
3/8	5/16	3/4
1/2	3/8	1

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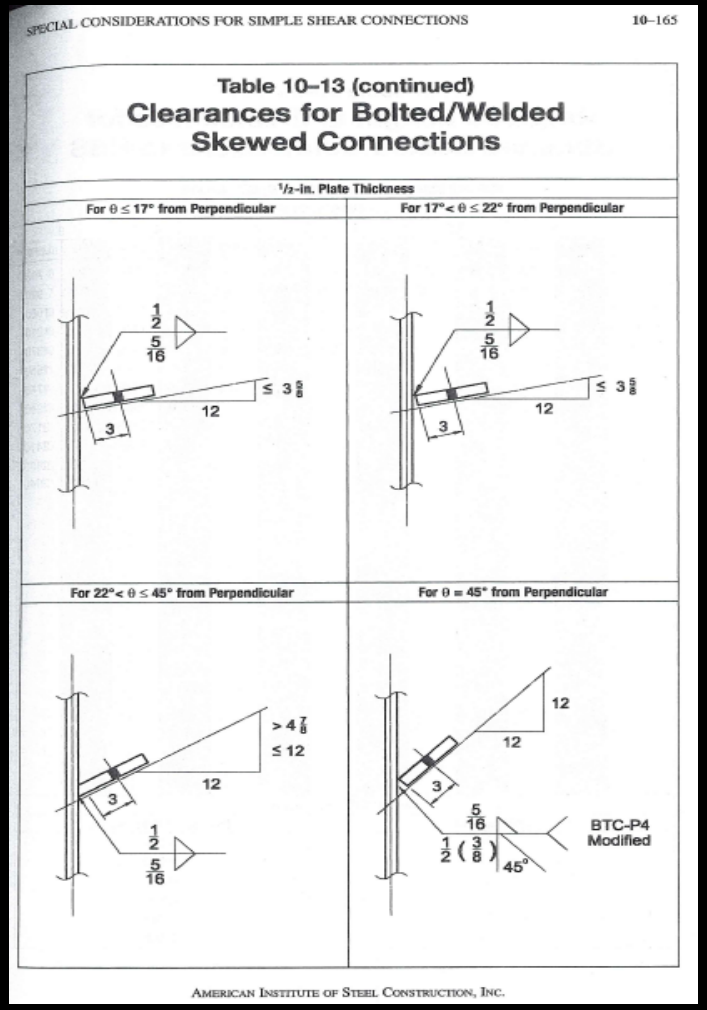

SPECIAL CONSIDERATIONS FOR SIMPLE SHEAR CONNECTIONS 10–165

Table 10–13 (continued)
Clearances for Bolted/Welded Skewed Connections

1/2-in. Plate Thickness

For θ ≤ 17° from Perpendicular	For 17° < θ ≤ 22° from Perpendicular
For 22° < θ ≤ 45° from Perpendicular	For θ = 45° from Perpendicular

BTC-P4 Modified

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WELD ECONOMY

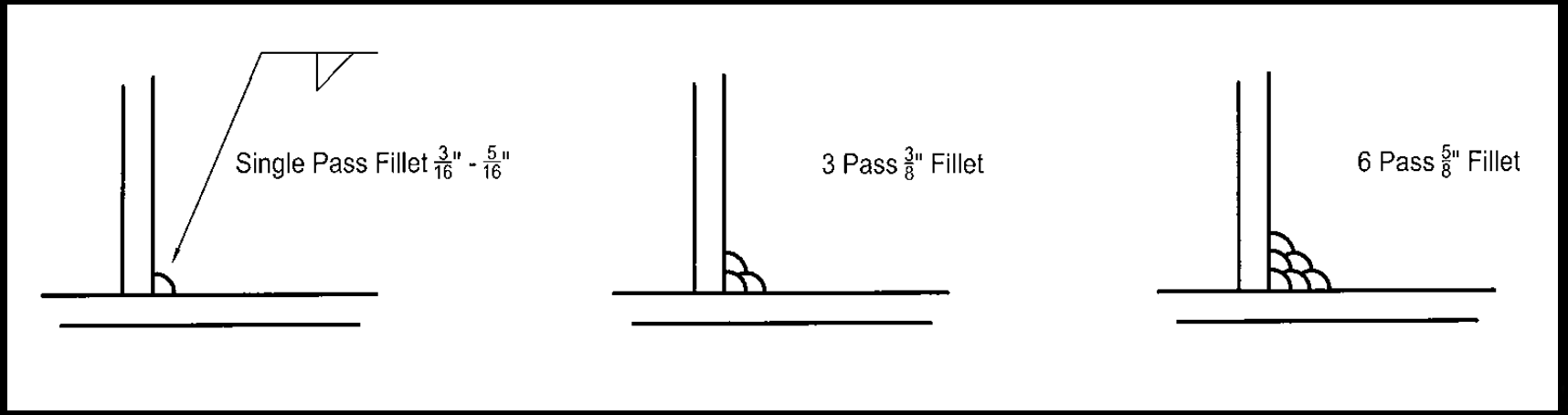
LBYD

Weld Economy

- Fillet Welds are Economical.

- 3/16, 1/4, & 5/16 Fillet Welds are “One Pass” Welds.

- 3/8 and Greater Fillet Welds are Multiple Pass Welds.



LBYD

Weld Economy

Multi-Pass Welds:

D = 5 /16 fillet weld size $L_1 = 12\,in$

$$D \cdot L_1 \cdot 1.392 \frac{kips}{in} = 83.5\,kips$$

3/8" fillet weld — weld passes required: $p = 3$

$$L_2 = \frac{83.5 kips}{\left(1.392 \frac{kips}{in}\right)(6)} \qquad L_2 = 10\,in \qquad L_2 \cdot p = 30\,in$$

5/8" fillet weld — weld passes required: $p = 6$

$$L_3 = \frac{83.5 kips}{\left(1.392 \frac{kips}{in}\right)(10)} \qquad L_3 = 6\,in \qquad L_3 \cdot p = 36\,in$$

LBYD

Weld Economy

Order of Economy:

1. Fillet Welds.

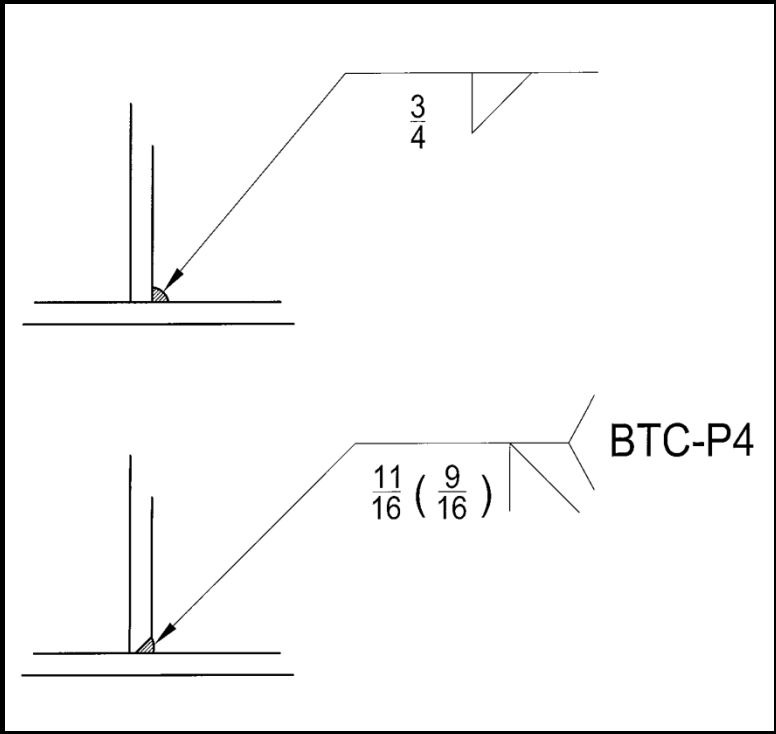
2. Partial-Joint Penetration Welds (PJP).

3. Complete-Joint Penetration Welds (CJP).

LBYD

Weld Economy

Maximum Fillet Weld Sizes Before Considering Partial Penetration Welds – 5/8” to 3/4”



3/4” Fillet Welds

Shear Strength = 16.7 k/in. (factored)

Area of 3/4” Fillet Weld = 0.281 sq in

Partial Penetration Weld with Strength = 16.7 k/in. (factored)

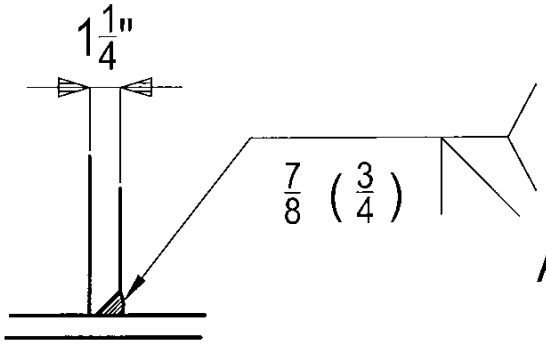
E = 0.53 in. Bevel = 11/16 in.

Area of Partial Pen = 0.236 sq in

LBYD

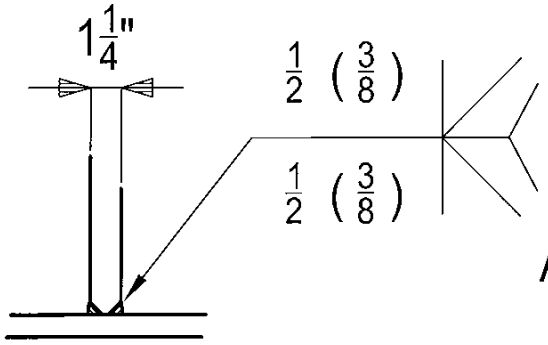
Weld Economy

Two ‘Welds’ Are Better Than One:



BTC-P4

Area of Bevel = 0.383 sq in.



BTC-P5

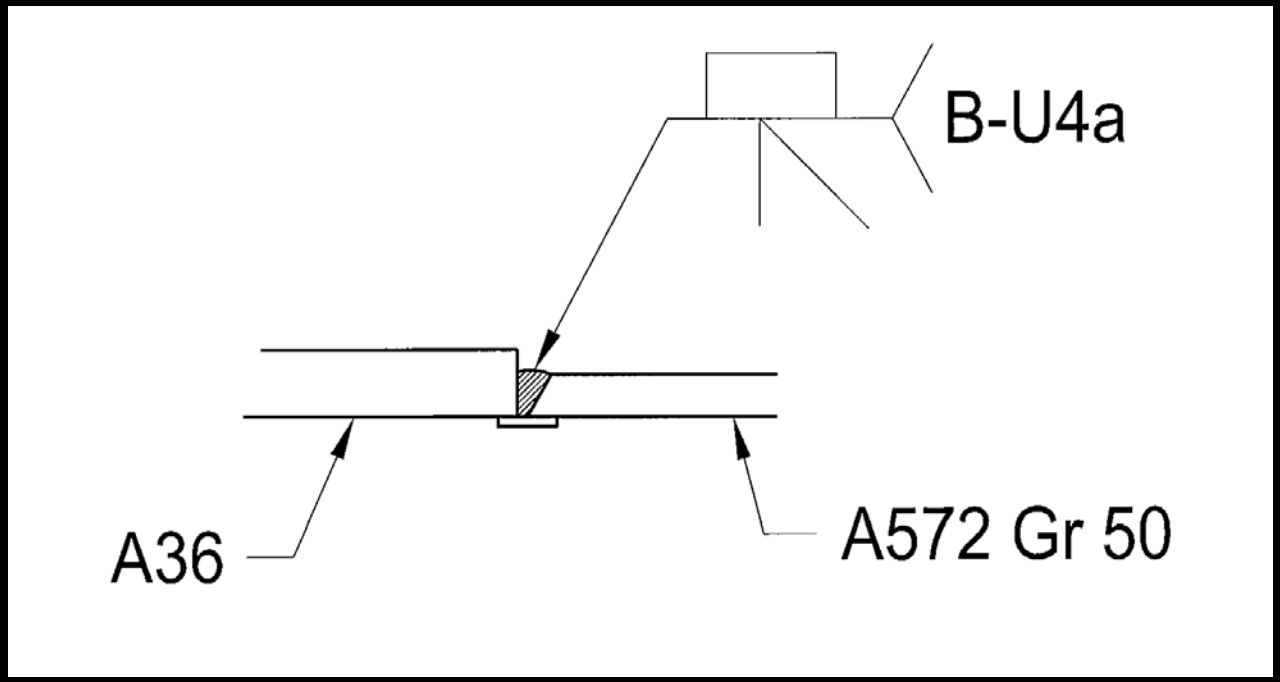
Area of Bevels = 0.25 sq in.

Weld Economy

Full Penetration Welds:

Weld Strength = Strength of Lesser Grade Material

Increasing Thickness of Lesser Grade Material Does NOT Increase the Strength of the Welded Joint



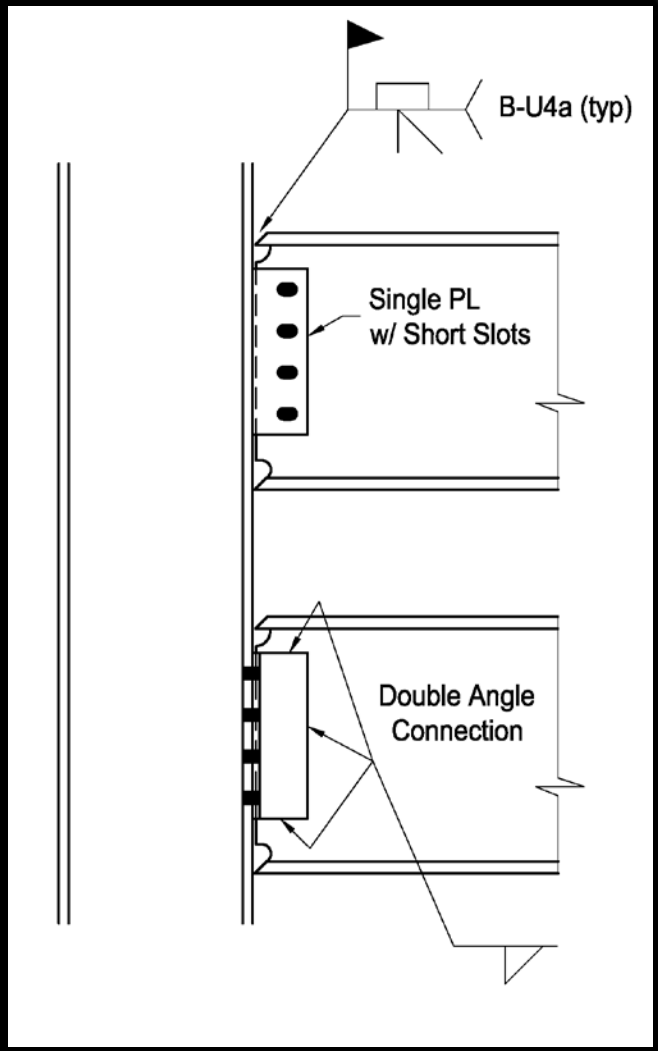
LBYD

SPECIAL TOPICS

Special Topics

Transverse Weld Shrinkage
Single Plate with Short Slots – DO NOT Pretension Bolts Prior to Welding Beam Flanges.

<u>NOT RECOMMENDED:</u>
Double Angle Web Connection – Angles Restrict Transverse Weld Shrinkage



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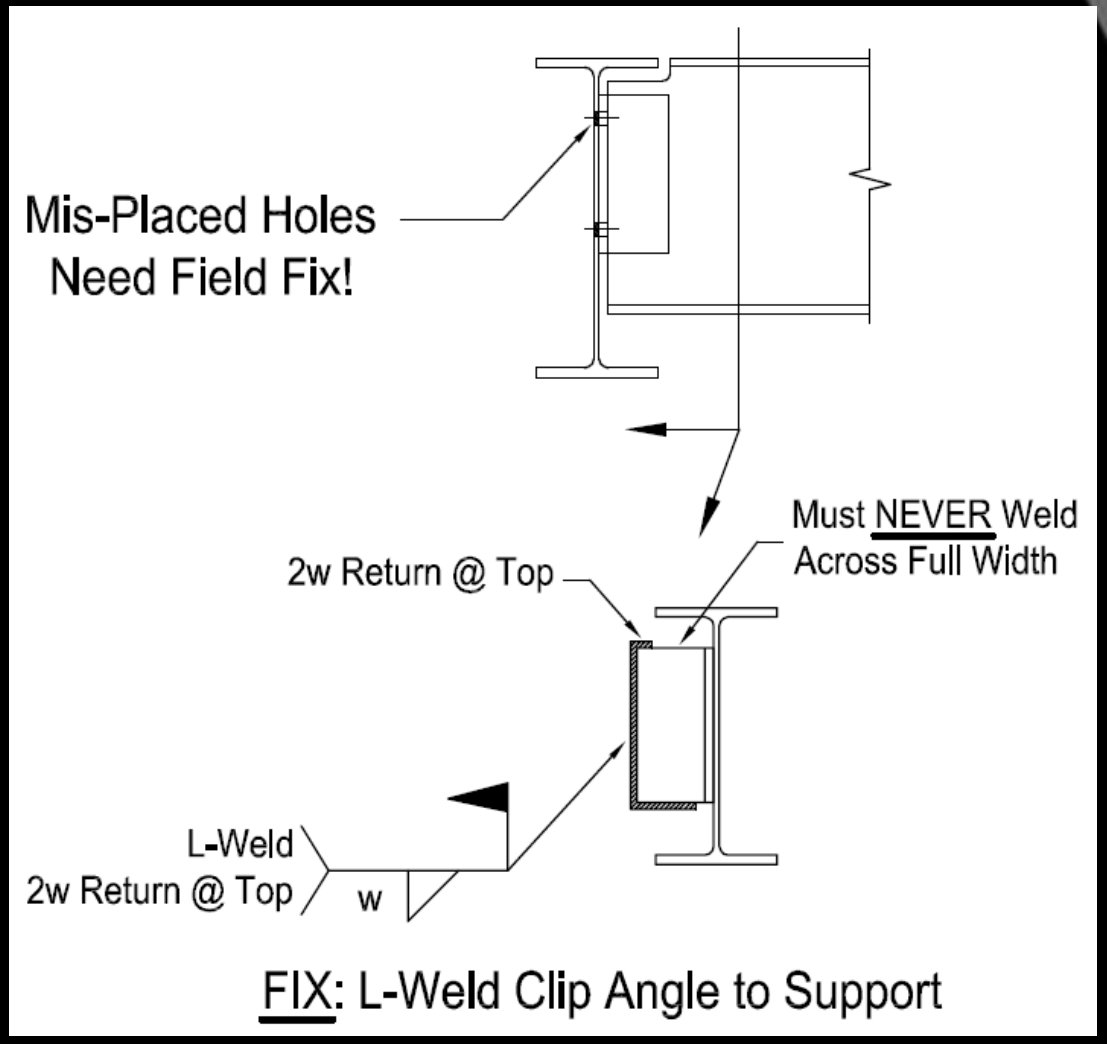
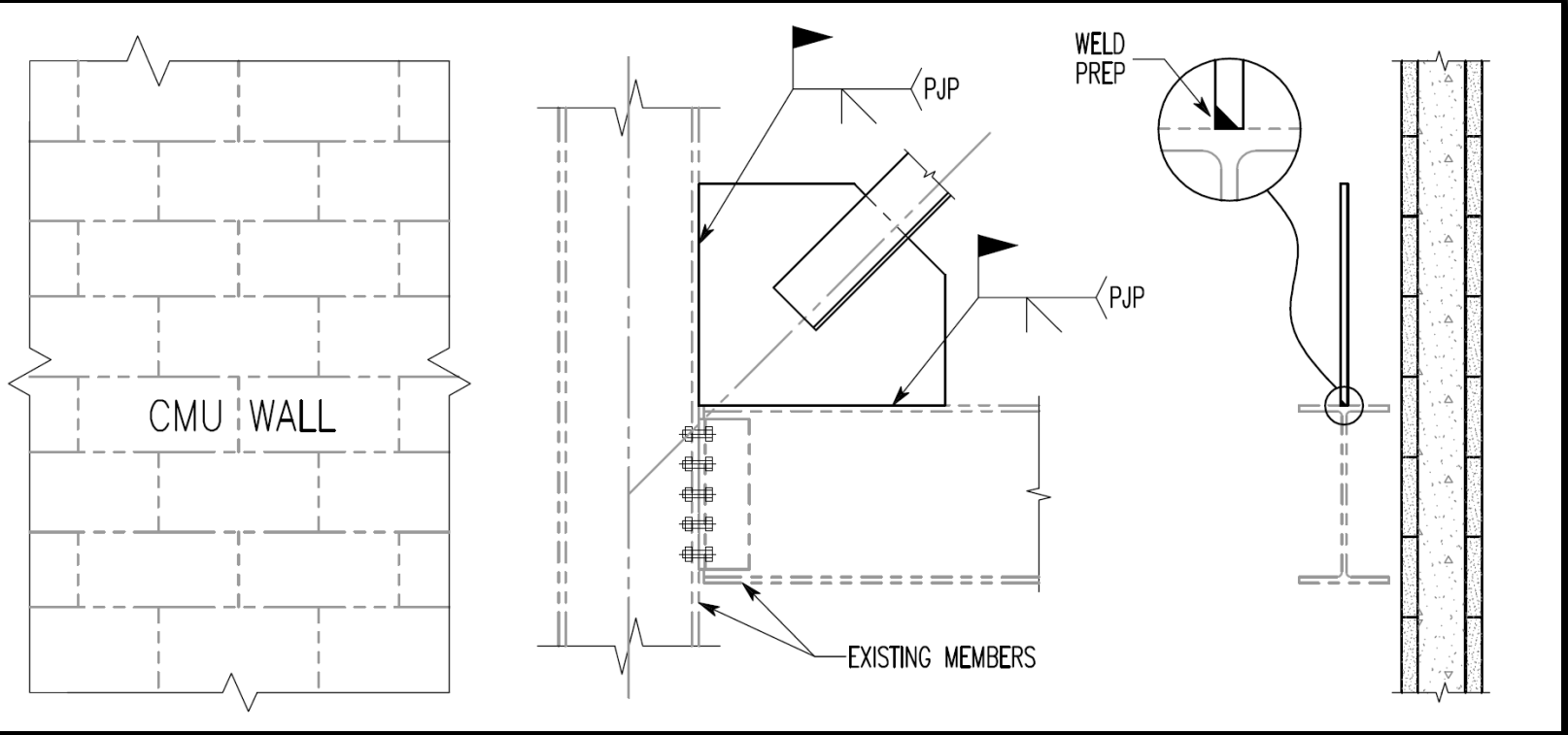
Special Topics

- FIELD FIX:



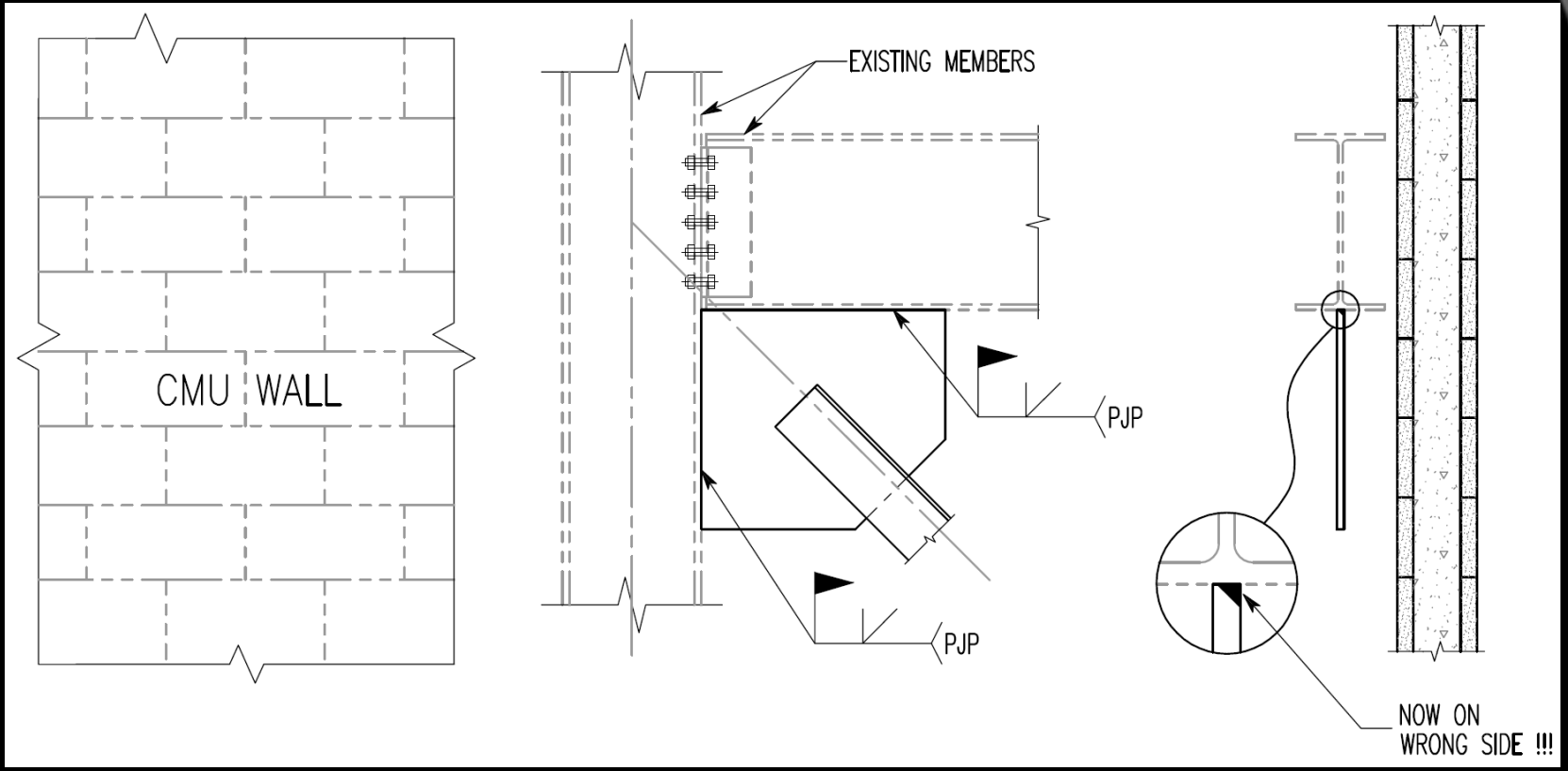
Special Topics

1) ADD BRACING TO EXISTING BUILDING:

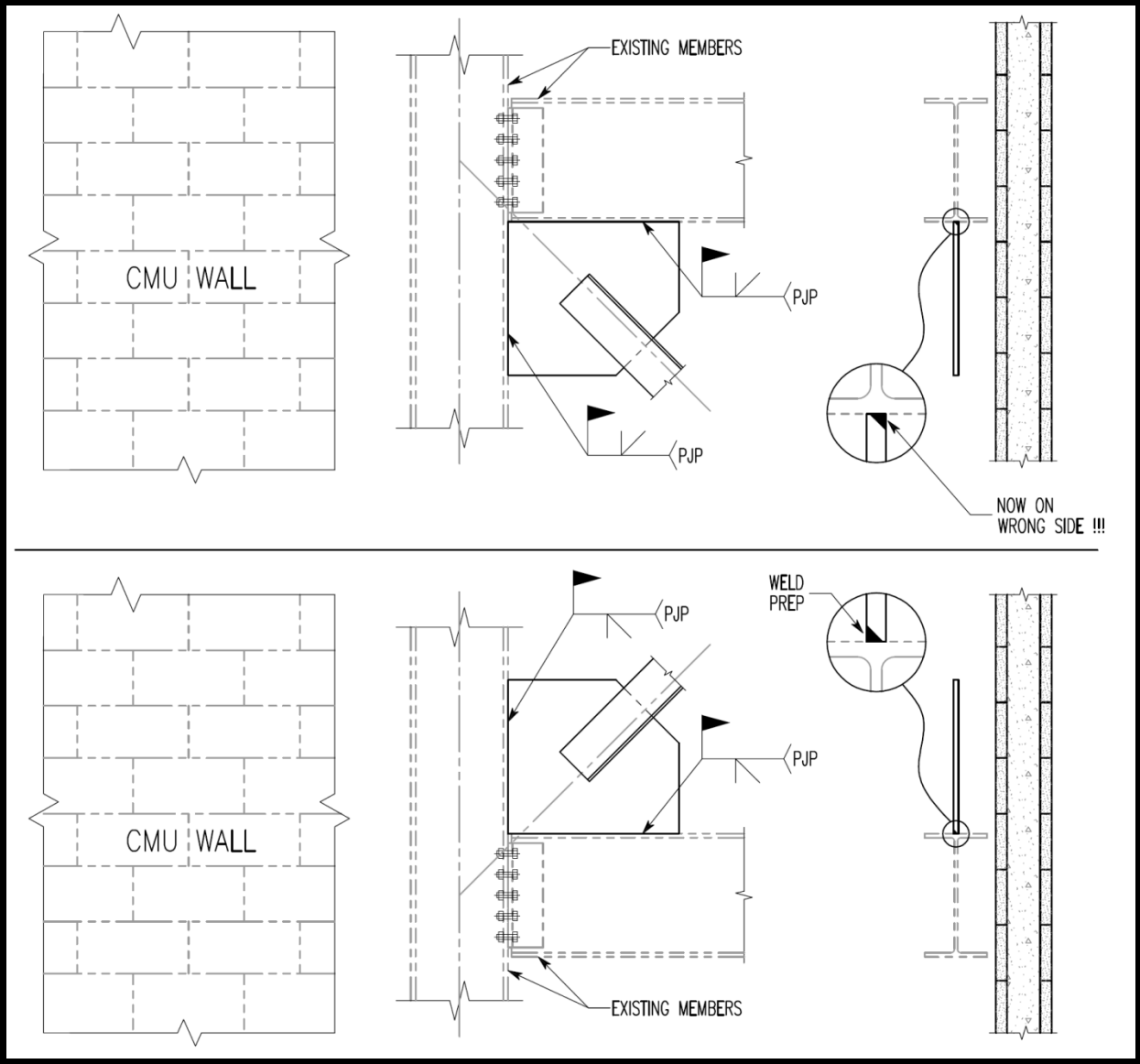


Special Topics

2) DETAIL IS MIRRORED OR ‘FLIPPED’ FOR UPPER END OF BRACE:

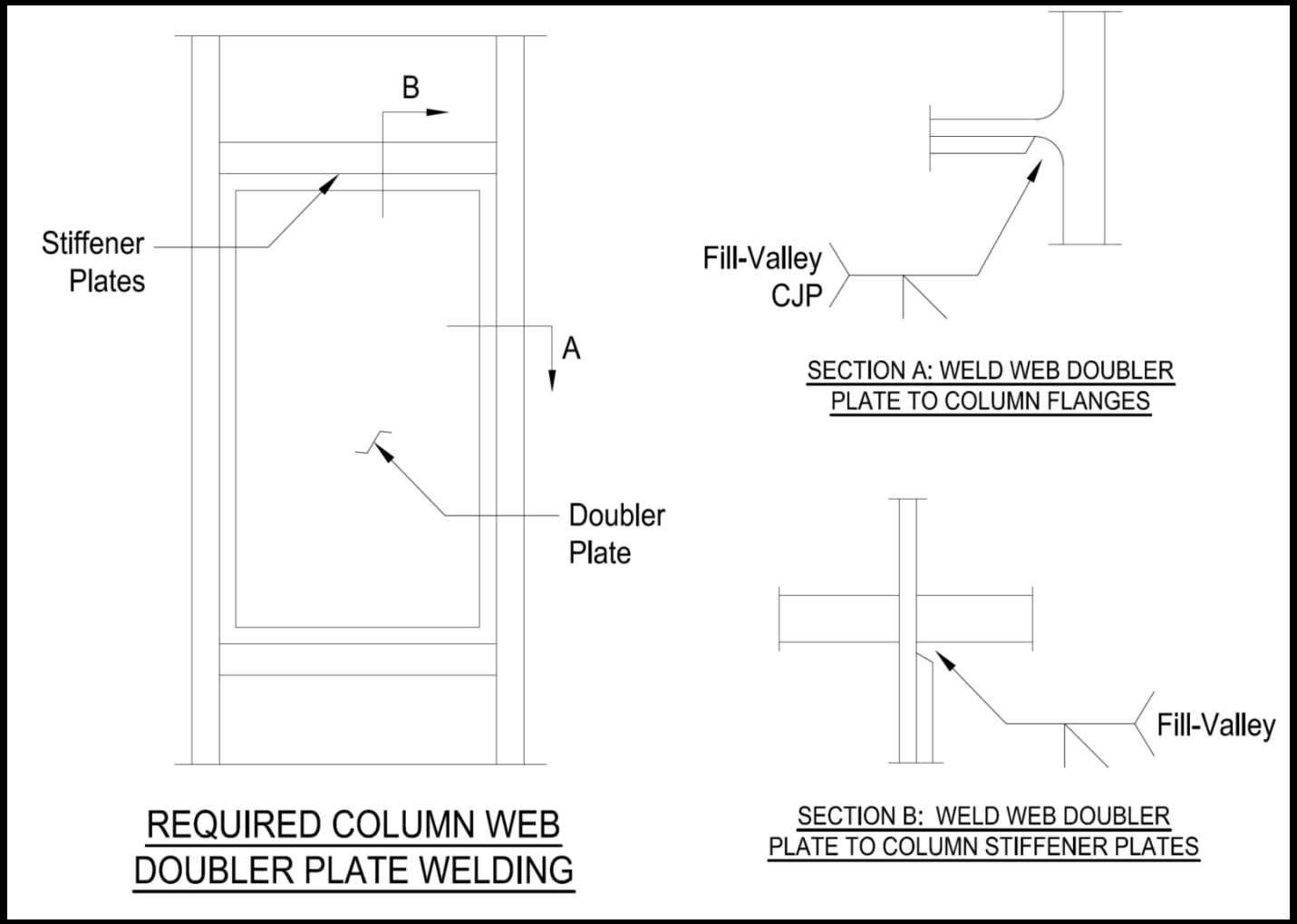


Special Topics



Special Topics

- COLUMN WEB DOUBLER WELDING:



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THANK YOU!!

QUESTIONS?

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For a copy of the slides from today please email Robert at

rwhyte@lbyd.com

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