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Wei-Wen Yu Center for Cold-Formed Steel Structures

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AISI Specification Changes

This Technical Bulletin summarizes recently approved changes to Section J2 Welded Connections of the *North American Specification for the Design of Cold-Formed Steel Structural Members*, AISI S100. These approved Committee on Specifications changes will be published in the next edition of AISI 100. They are being summarized here to enable users of the specification to implement the new provisions with approval of the local building official. This information is printed with permission from the American Iron and Steel Institute.

J2.2 Welding

The titles for Figures J2.2.1-2 and J2.2.2.1-2 were changed from double thicknesses to multiple thicknesses to reflect the intent of the *Specification* to not limit the number of welded sheets to two sheets. In 2019, AWS made a parallel change to the AWS D1.3 Standard.

In 2020, the requirement that Fxx must be greater than Fu was deleted in Section J2.2.3 because the requirement for matching weld metal was removed from AWS D1.3 in 2017, and the *nominal strength* [*resistance*] equations consider both the ultimate strength of the sheet and the electrode

In 2018, the *safety* and *resistance factors* for arc spot welds and arc plug welds were modified based on work by Blackburn, Sputo, and Meyer (2016). The equation for d_e was also revised in 2017 (Blackburn, Sputo and Meyer, 2016) as summarized by the following:

J2.2.2 Shear

J2.2.2.1 Shear Strength for Sheet(s) Welded to a Thicker Supporting Member

The *available shear strength* [*factored resistance*], P_{av}, of each arc spot weld between the sheet or sheets and a thicker supporting member shall be the smaller value which is computed with the *nominal shear strength* [*resistance*], P_{nv}, determined by using either (a) or (b), and the corresponding *safety factor* and *resistance factors* applied in accordance with the applicable design method in Section B3.2.1, B3.2.2, or B3.2.3.

(a) $P_{nv} = \frac{\pi d_e^2}{4} 0.75 F_{xx}$ (*Eq.* J2.2.2.1-1)

Ω = 2.60 (*ASD*)
ϕ = 0.60 (*LRFD*)
= 0.50 (*LSD*)

(b) For $(d_a/t) \le 0.815\sqrt{E/F_u}$

$P_{nv} = 2.20\, t d_a F_u$ (*Eq*. J2.2.2.1-2)

Ω = 1.95 (*ASD*)
ϕ = 0.80 (*LRFD*)
= 0.65 (*LSD*)

For $0.815\sqrt{E/F_u} < (d_a/t) < 1.397\sqrt{E/F_u}$

$$P_{nv} = 0.280\left[1 + 5.59\frac{\sqrt{E/F_u}}{d_a/t}\right] t d_a F_u \quad \text{(Eq. J2.2.2.1-3)}$$

Ω = 1.75 (*ASD*)
ϕ = 0.85 (*LRFD*)
= 0.70 (*LSD*)

For $(d_a/t) \ge 1.397\sqrt{E/F_u}$

$P_{nv} = 1.40\, t d_a F_u$ (*Eq*. J2.2.2.1-4)

Ω = 3.30 (*ASD*)
ϕ = 0.45 (*LRFD*)
= 0.35 (*LSD*)

where

P_{nv} = *Nominal shear strength* [*resistance*] of arc spot weld

d_e = Effective diameter of fused area at plane of maximum shear transfer
= Greater of 0.7d – 1.5t and 0.45d (*Eq*. J2.2.2.1-5)

where

d = Visible diameter of outer surface of arc spot weld

t = Total combined base steel *thickness* (exclusive of coatings) of sheets involved in shear transfer above plane of maximum shear transfer

F_{xx} = *Tensile strength* of electrode classification

d_a = Average diameter of arc spot weld at mid-*thickness* of t where $d_a = (d - t)$ for single sheet or multiple sheets not more than four lapped sheets over a supporting member. See Figures J2.2.2.1-1 and J2.2.2.1-2 for diameter definitions.

E = Modulus of elasticity of steel

F_u = *Tensile strength* as determined in accordance with Section A3.1 or A3.2

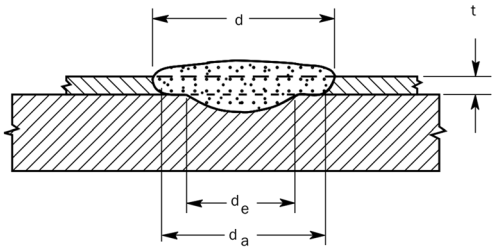

Figure J2.2.2.1-1 Arc Spot Weld – Single Thickness of Sheet

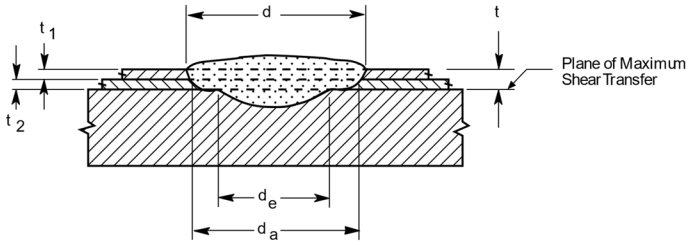

Figure J2.2.2.1-2 Arc Spot Weld – Multiple Thickness of Sheet

J2.2.2.2 Shear Strength for Sheet-to-Sheet Connections

The *nominal shear strength* [*resistance*], P_{nv}, for each weld between two sheets of equal *thickness* shall be determined in accordance with Eq. J2.2.2.2-1. The *safety factor* and *resistance factors* in this section shall be used to determine the *available strength* [*factored resistance*], P_{av}, in accordance with the applicable design method in Section B3.2.1, B3.2.2, or B3.2.3.

$P_{nv} = 1.65td_aF_u$ (*Eq.* J2.2.2.2-1)

$\Omega = 1.95$ (*ASD*)

$\phi = 0.80$ (*LRFD*)

$= 0.65$ (*LSD*)

where

P_{nv} = *Nominal shear strength* [*resistance*] of sheet-to-sheet *connection*

t = Base steel *thickness* (exclusive of coatings) of single welded sheet

d_a = Average diameter of arc spot weld at mid-thickness of t. See Figure J2.2.2.2-1 for diameter definitions

$= (d - t)$ (Eq. J2.2.2.2-2)

where

d = Visible diameter of the outer surface of arc spot weld

F_u = *Tensile strength* of sheet as determined in accordance with Section A3.1 or A3.2
In addition, the following limits shall apply:
(a) $F_u \leq 59$ ksi (407 MPa or 4150 kg/cm^2),
(b) $F_{xx} > F_u$, and
(c) 0.028 in. (0.71 mm) ≤ t ≤ 0.0635 in. (1.61 mm).
See Section J2.2.2.1 for definition of F_{xx}.

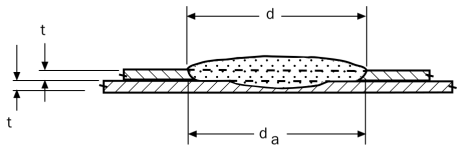

Figure J2.2.2.2-1 Arc Spot Weld – Sheet to Sheet

J2.2.3 Tension

The uplift *available tensile strength* [*factored resistance*], P_{at}, of each concentrically loaded arc spot weld connecting sheet(s) and supporting member shall be the smaller value which is computed with the *nominal tensile strength* [*resistance*], P_{nt}, determined using either Eq. J2.2.3-1 or Eq. J2.2.3-2, as follows, and the *safety factors* and *resistance factors* applied in accordance with the applicable design method in Section B3.2.1, B3.2.2, or B3.2.3.

$$P_{nt} = r\frac{\pi d_e^2}{4}F_{xx} \qquad (Eq.\ J2.2.3\text{-}1)$$

$$P_{nt} = r0.8(F_u/F_y)^2\, t\, d_a F_u \qquad (Eq.\ J2.2.3\text{-}2)$$

where
r = Weld effectiveness reduction factor determined in accordance with Table J2.2.3-1
t = Thickness as defined in Table J2.2.3-1
See Section J2.2.2.1 for definitions of other variables.
The *safety* and *resistance factors* are provided in Table J2.2.3-1.

Table J2.2.3-1
Safety and Resistance Factors, Thickness Definition, and Weld Effectiveness Reduction

Equation Number	Sheet Configuration	Panel and Deck			Other			Thickness t	Reduction Factor r
		Ω (ASD)	ϕ (LRFD)	ϕ (LSD)	Ω (ASD)	ϕ (LRFD)	ϕ (LSD)		
J2.2.3-1	All	3.05	0.50	0.35	3.90	0.40	0.30	Total thickness of sheet(s)	0.5; 1.0 with weld washer
J2.2.3-2	Single or Multiple sheets	2.00	0.75	0.60	2.35	0.65	0.50	Total thickness of sheet(s)	1.0
	Sidelap *connections* in a deck system	2.90	0.55	0.40	3.50	0.45	0.35	Thickness of topmost sheet	1.0
	Eccentrically loaded *connections*	2.30	0.65	0.50	2.75	0.55	0.45	Total thickness of sheet(s)	0.5; 1.0 with weld washer

The following limits shall apply:

(a) $t\, d_a\, F_u \le 3$ kips (13.3 kN or 1360 kg),

(b) $F_{xx} \ge 60$ ksi (410 MPa or 4220 kg/cm^2),

(c) $F_u \le 82$ ksi (565 MPa or 5770 kg/cm^2) (of connecting sheets), and

(d) $F_{xx} > F_u$.

Where it is shown by measurement that a given weld procedure consistently gives a larger effective diameter, d_e, or average diameter, d_a, as applicable, this larger diameter is permitted to be used provided the particular welding procedure used for making those welds is followed.

J2.2.4 Combined Shear and Tension on an Arc Spot Weld

For arc spot weld *connections* subjected to a combination of shear and tension, the following interaction check shall be applied:

If $\left(\frac{\overline{T}}{P_{at}}\right)^{1.5} \le 0.15$, no interaction check is required.

If $\left(\frac{\overline{T}}{P_{at}}\right)^{1.5} > 0.15$,

$$\left(\frac{\overline{V}}{P_{av}}\right)^{1.5} + \left(\frac{\overline{T}}{P_{at}}\right)^{1.5} \le 1 \qquad \text{(}Eq.\text{ J2.2.4-1)}$$

where

$\overline{T}$ = *Required tensile strength* [tensile force due to *factored loads*] per *connection* fastener determined in accordance with *ASD*, *LRFD*, or *LSD load combinations*

$\overline{V}$ = *Required shear strength* [shear force due to *factored loads*] per *connection* fastener, determined in accordance with *ASD*, *LRFD*, or *LSD load combinations*

P_{at} = *Available tension strength* [*factored resistance*] as given by Section J2.2.3

P_{av} = *Available shear strength* [*factored resistance*] as given by Section J2.2.2

In addition, the following limitations shall be satisfied:

(a) $F_u \le 105$ ksi (724 MPa or 7380 kg/cm^2),

(b) $F_{xx} \ge 60$ ksi (414 MPa or 4220 kg/cm^2),

(c) $td_aF_u \le 3$ kips (13.3 kN or 1360 kg),

(d) $F_u/F_y \ge 1.02$, and

(e) 0.47 in. (11.9 mm) $\le d \le$ 1.02 in. (25.9 mm).

See Section J2.2.2.1 for definition of variables.

J2.3.2 Shear

J2.3.2.1 Shear Strength for Sheet(s) Welded to a Thicker Supporting Member

The *available shear strength* [*factored resistance*], P_{av}, of arc seam welds shall be the smaller value which is determined with the *nominal shear strength* [*resistance*], P_{nv}, determined by using either Eq. J2.3.2.1-1 or Eq. J2.3.2.1-2, and the *safety factor* and *resistance factors* applied in accordance with the applicable design method in Section B3.2.1, B3.2.2, or B3.2.3.

$$P_{nv} = \left(\frac{\pi d_e^2}{4} + Ld_e\right)0.75F_{xx} \qquad (Eq.\ J2.3.2.1\text{-}1)$$

$$P_{nv} = 2.5tF_u(0.25L + 0.96d_a) \qquad (Eq.\ J2.3.2.1\text{-}2)$$

Ω = 2.45 (*ASD*)

ϕ = 0.60 (*LRFD*)

= 0.50 (*LSD*)

where

P_{nv} = *Nominal shear strength* [*resistance*] of arc seam weld

d_e = Effective width of arc seam weld at fused surfaces

= 0.7d – 1.5t (*Eq.* J2.3.2.1-3)

where

d = Visible width of arc seam weld

L = Length of seam weld not including circular ends
(For computation purposes, L shall not exceed 3d)

d_a = Average width of arc seam weld

= (d – t) for single or double sheets (*Eq.* J2.3.2.1-4)

F_u, F_{xx}, and t = Values as defined in Section J2.2.2.1

J2.3.2.2 Shear Strength for Sheet-to-Sheet Connections

The *nominal shear strength* [*resistance*], P_{nv}, for each weld between two sheets of equal *thickness* shall be determined in accordance with Eq. J2.3.2.2-1. The *safety factor* and *resistance factors* in this section shall be used to determine the *available strength* [*factored resistance*], P_{av}, in accordance with the applicable design method in Section B3.2.1, B3.2.2 or B3.2.3.

$P_{nv} = 1.65 t d_a F_u$ (*Eq.* J2.3.2.2-1)

$\Omega = 1.95$ (*ASD*)

$\phi = 0.80$ (*LRFD*)

$= 0.65$ (*LSD*)

where

P_{nv} = *Nominal shear strength* [*resistance*] of sheet-to-sheet *connection*

d_a = Average width of arc seam weld at mid-*thickness*. See Figure J2.3.2.2-1 for width definitions.

$= (d - t)$ (Eq. J2.3.2.2-2)

where

d = Visible width of the outer surface of arc seam weld

t = Base steel *thickness* (exclusive of coatings) of single welded sheet

F_u = *Tensile strength* of sheet as determined in accordance with Section A3.1 or A3.2

In addition, the following limits shall apply:

(a) $F_u \leq 59$ ksi (407 MPa or 4150 kg/cm^2),

(b) $F_{xx} > F_u$, and

(c) 0.028 in. (0.711 mm) ≤ t ≤ 0.0635 in. (1.61 mm).

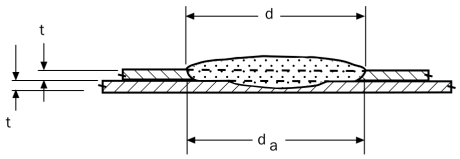

Figure J2.3.2.2-1 Arc Seam Weld – Sheet to Sheet

J2.5 Arc Plug Welds

Arc plug welds, where permitted by this *Specification*, shall be designed using the provisions of Section J2.2. The minimum diameter of the hole through which the plug weld is created shall not be less than 3/8 in. (9.53 mm), nor that required to develop an effective weld diameter, d_e, not less than 3/8 in. (9.53 mm).

Reference:

Blackburn, B.P., T. Sputo, and C. Meyer (2016), *Resistance of Arc Spot Welds – Update to Provisions*, AISI Research Report RP 16-1, AISI, 2016.

Disclaimer

The material contained herein has been developed by a joint effort of the American Iron and Steel Institute (AISI) Committee on Specifications, CSA Group Technical Committee on Cold

Formed Steel Structural Members (S136), and Camara Nacional de la Industria del Hierro y del Acero (CANACERO) in Mexico. The organizations and the Committees have made a diligent effort to present accurate, reliable, and useful information on cold-formed steel design. The Committees acknowledge and are grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. Specific references are included in the Commentary on the Specification.

With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material may eventually become dated. It is anticipated that future editions of this Specification will update this material as new information becomes available, but this cannot be guaranteed.

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