Changes
AASHTO/AWS D1.5 Bridge Welding Code
2020 Edition

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High Steel Structures
QAW
15 February 2020

D1J AASHTO / AWS D1J Subcommittee on Bridge Welding
April 11th, 2019
Miami, FL

Voting Members Present

Ronnie Medlock, Chair	AWS	High Steel Structures, LLC
Nina Choy, Vice Chair	AASHTO	California Department of Transportation
Jon Edwards	General Interest	DOT – Quality Services
Karl Frank (P: Gilmer)	AWS	NSBA
Heather Gilmer	General Interest	HRV
Mary Grieco	AASHTO	Massachusetts Department of Transportation
Brandon Harris	AWS	W&W AFCO Steel – AFCO Division
Preston A. Huckabee	Gill Engineering Associates	
Nate Lindell	AWS	Oregon Iron Works
Tim McCullogh	AASHTO	FDOT State Materials Office
David McQuaid	AWS	D. L. McQuaid & Associates
Robert Mertz (P: Choy)		Alta Vista Solutions
Duane Miller	General Interest	The Lincoln Electric Company
Kent Nelson (P: Grieco)	AASHTO	Missouri Department of Transportation
Todd Niemann	AASHTO	Minnesota Department of Transportation
Randy Ringstmeyer	AASHTO	WYDOT
Thomas Rogers	General Interest	Modjeski & Masters
Robert Stachel	General Interest	HRV

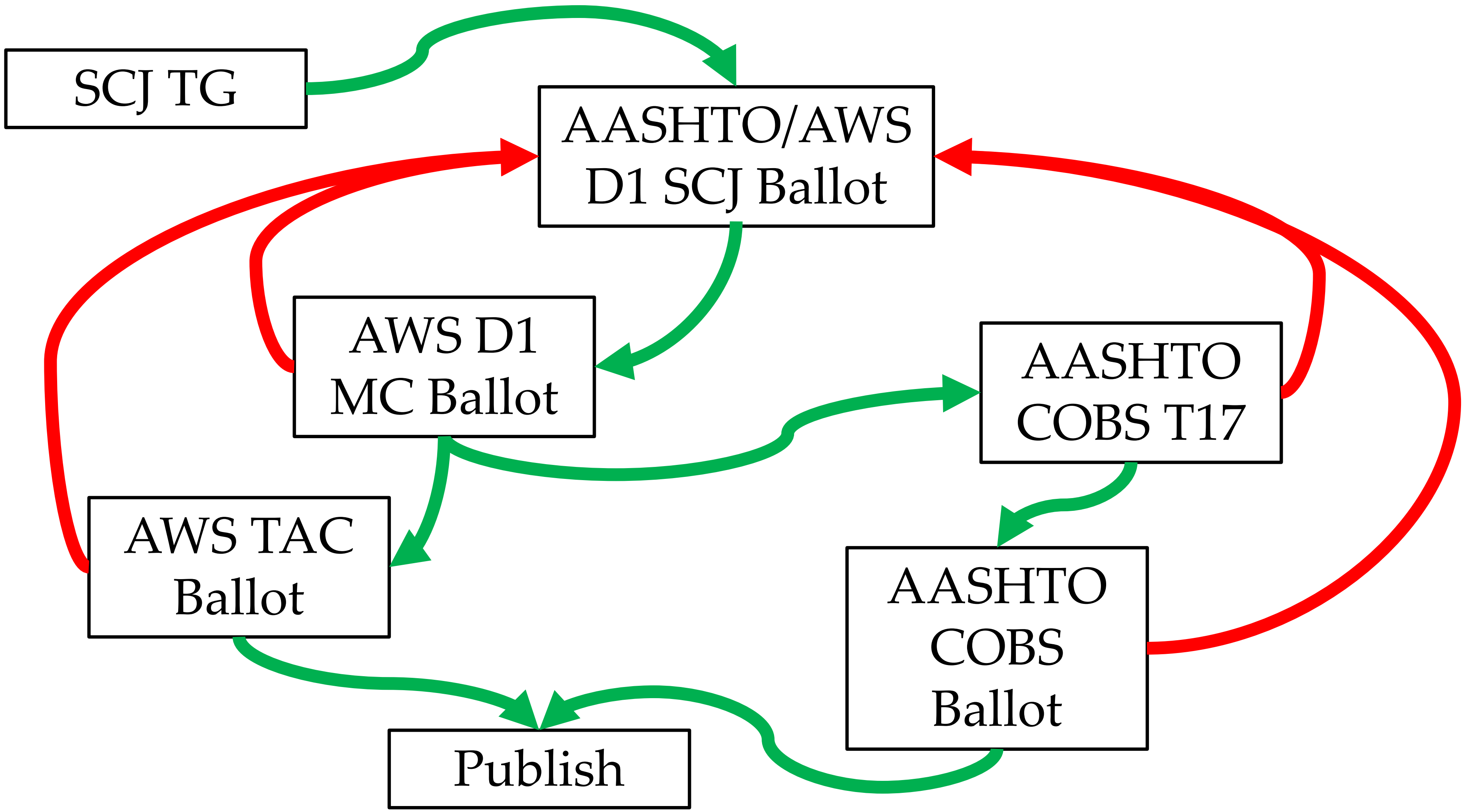
Retired; T17 accepting nominations

Retired; Nick Shrawder, PennDOT, nominated

Meetings

- 2018
  - Spring: Miami
  - Fall: Denver (Aurora)
- 2019
  - Spring: Miami
  - Fall: Vancouver
- 2020
  - Spring: Miami
  - Fall: Columbus

- 2019 05 conf call - PAUT
- 2019 03 04 - D1.5 teleconference
- 2019 02 20 - D1.5 teleconference
- 2019 02 07 - D1 teleconference
- 2018 11 1st bridge teleconference
- 2018 07 4th bridge teleconference
- 2018 07 3rd bridge teleconference
- 2018 06 2nd bridge teleconference
- 2018 05 1st bridge teleconference
- 2018 04 03 Teleconference
- 2017 11 2nd bridge teleconference
- 2017 11 1st bridge teleconference


SCJ TG
AASHTO/AWS D1 SCJ Ballot
AWS D1 MC Ballot
AASHTO COBS T17
AWS TAC Ballot
AASHTO COBS Ballot
Publish

2020 Overview

PROPOSED D1.5M/D1.5:2020
(Changes shown using TRACK CHANGES)

45.		General	Miller, DK 4	YES	Comment: Have the proposed stud provisions been reviewed by the stud task group? If not, they should be. Proposed Resolution:	**Comment Type:** Substantive **Action/Resolution:** Reject **Revision (if applicable):** **Supporting TAC Rule for Rejection (if applicable):** New Business **Rationale for Action:** no substantive changes to requirements for stud pull out, but stud group can be conttacted		

on

E08 R11 -
E08 R12 -
E08 R13 -

Task:	Revise 2015 edition to incorporate new provisions.
Affected Clauses:	**Code Paragraph(s):** 2.17.3, 3.2.2, 3.2.2.1, 3.2.2.2, 3.2.3.7(2), 3.2.4, 3.2.6, 3.3.7.4, 3.6.2.1(5), 3.6.2.1(6), 3.8.1, 3.10, 3.13.3, 4.10.6.1, 4.11.6.1, 5.26.1.1,

49.	15	Annex D	Campbell, RD 18	YES	Comment: Why on earth do we need to define 'machine'? This is a dictionary term. We could add many examples to this list. Proposed Resolution: As New Business for the next edition, consider deleting term and definition of 'machine'	**Comment Type:** Substantive **Action/Resolution:** Reject **Revision (if applicable):** **Supporting TAC Rule for Rejection (if applicable):** New Business **Rationale for Action:** Commenter may wish to suggest TG to assess current terms and definitions		

Commentary: 3.7.7, C-3.7.7.4, C-3.10, C-4.3, C-4.10.6.1, C-4.11.6.1, C-6.10.3, C-6.10.3.2, C-6.19.5.2, C-6.19-6.1, C-6.26.2, C-6.26.4, C-7.5.5.3, C-7.5.5.4, C-7.7.5, C-7.7.5.1, C-7.7.5.5, C-12.13.3,

Changes for 2020? Generally

- Few big shakes
- Less prescription / more desired condition (i.e., performance specifications)
- Corrections / being more precise

Base Metals

- No longer say, "Code is applicable to A709 steels" – now rather list the specific grades and types
- ASTM can add grades to any specification whenever it suits them

Always be cautious when specifying D1.5 that it is applicable to the materials you are welding

1.2.2 Approved Base Metals. ~~Unless otherwise specified, b~~Base metals to be welded under this code shall meet the requirements of the latest edition ~~of AASHTO M 270M/M 270~~ (ASTM A709/A709M) for the following grades:

1. ~~Grade~~ 250 [36],
2. 345 [50] (Type 1, 2, or 3),
3. 345S [50S],
4. 345W [50W],
5. HPS 345W [HPS 50W],
6. HPS 485W [HPS 70W], or
7. HPS 690W [HPS 100W]~~, as shown on the plans or described in the specifications~~. ~~All Grade 345 [50] steel that is to be welded shall be Type 1, 2, or 3. Other steels may be approved by the Engineer.Thickness limitations shall not apply to bearing components.~~

~~The provisions of this code are not intended for use with steels having a minimum specified yield strength over 690 MPa [100 ksi].~~

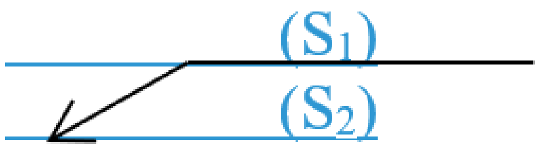
Discontinuities

- What for discontinuities, flaws, and defects … ?
  - Discontinuity – any geometric disruption to the weld; can be both surface and internal
  - Flaw – an undesirable discontinuity
  - Defect – a rejectable discontinuity
- As of 2020
  - Eliminating use of “flaw”
  - Changing all uses to either “discontinuity” or “defect”, depending upon when or not the discontinuity is rejectable

Weld symbol alignment with AISC

2.1.3.1 *(last paragraph)*

~~The welding symbol with dimensions above or below the arrow designate a PJP weld as follows:~~
The welding symbol with the effective groove weld size (S) above or below the reference line designates a PJP weld as follows:



Where
(S_1) = effective weld size, other side
(S_2) = effective weld size, arrow side

2.13.2 Minimum Effective Weld Size. The minimum effective weld size of PJP square-, single- or double-V-, bevel-, J-, and U-groove welds shall be as shown in Table 2.2.

Shop or working drawings shall specify the depth of groove (D)~~(S)~~ applicable for the effective weld size (S) ~~(E)~~ required for the welding process and position of welding to be used.

Address incorrect use of "E70" and "E80"

- Have incorrectly been saying "E70" and "E80" when we mean, generally, electrodes of 70 ksi and 80 ksi strength.

2nd paragraph **C-2.1.6**

In most cases, ~~E70 or E80~~ weld metal classified with minimum specified tensile strength of 70 or 80 ksi will be used for undermatching applications. 70-ksi weld metal ~~E70~~ is generally preferable, but 80-ksi weld metal ~~E80~~ is often ~~required~~ used for unpainted weathering applications. ~~because, when atmospheric corrosion resistance is required for weathering steels, the added alloys result in E80 strength class weld metal.~~

Finished-to-bear

- Condition is not necessarily milled (this is one example of many places changed)
- 3.5.1.9 actually only refers to bearing stiffeners; here we now refer to the condition of 3.5.1.9.

2.17.3 Connections or Splices in Compression Members with ~~Milled~~ Finished-to-Bear Joints. If members subject only to compression are spliced and ~~full milled bearing~~ a finished-to-bear fit is provided, the ~~splice material and its~~ welding shall be arranged~~, unless otherwise stipulated by the applicable general specifications,~~ to hold all parts in alignment, and welds and contact areas ~~and~~ shall be proportioned to each carry 50% of the computed stress in the member. Where such members ~~have~~ are finished to achieve direct bearing ~~a full bearing fit~~ on base plates, contact tolerances ~~there~~ shall satisfy the second paragraph of 3.5.1.9 and there shall be sufficient welding to hold all parts securely in place.

Surfaces to be welded

- Adjusted detail in the Code, with emphasis on being as clean as necessary to achieve a good weld

~~3.2.1 Surfaces and edges to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other discontinuities which would adversely affect the quality or strength of the weld. Surfaces to be welded and surfaces adjacent to a weld shall also be free from loose or thick scale, slag, rust, moisture, grease, and other foreign material that would prevent proper welding or produce objectionable fumes. Mill scale that can withstand vigorous wire brushing, a thin rust-inhibitive coating, or antispatter compound may remain except that all mill scale shall be removed from the surfaces on which web-to-flange welds are to be made. This provision shall apply to all girders, stringers, beams, columns, towers, rigid frames, arches, truss chord members, and truss web members, but shall not apply to secondary (bracing) members. Mill scale shall be prohibited from remaining in the joint boundary of groove welds subject to calculated tensile stress.~~

3.2.1 General. Base metal shall be sufficiently clean to permit welds to be made that will meet the weld quality requirements of this code.

Surfaces to be welded

C-3.2.1 Poor quality of metal surfaces or edges can adversely affect the quality of welds made against those surfaces or edges. [*Remains under C-3.2*]

~~When steel was primarily cut by shearing, edges were often ragged and sometimes torn or cracked. Lamination in the sheared edges sometimes caused the metal to split apart. By code, most metal is now prepared for welding by thermal cutting. Thermal cut edges are generally superior to sheared edges, but still need to be inspected carefully to ensure that they conform to the requirements of this subclause.~~

~~Embedded and surface base metal discontinuities may affect~~

C-3.2.1 General. For quality welds, base metal cleanliness is important. However, it is neither required nor necessary for base metal to be perfectly clean before welds are made. It is difficult both to establish quantifiable limits of cleanliness and to measure to those limits therefore, this provision uses the practical standard of the resultant weld quality. If the base metal is sufficiently clean so as to facilitate a weld to be made that meets the requirements of this code, it is clean enough. If the resultant welds do not meet the weld quality requirements of this code, cleaner base metal may be required.

More surface prep for welding

3.2.2 Mill-Induced Surface Defects. Welds shall not be placed on surfaces that contain fins, tears, cracks, slag, or other base metal defects as defined in the base metal specifications.

C-3.2.2 Mill-Induced Surface Defects. The base metal to which welds are attached must be sufficiently sound so as to not affect the strength of the connection. Base metal defects may be repaired prior to the deposition of the prescribed weld. This subclause does not limit base metal repairs by welding.

Not welding over mill defects

3.2.3 Scale and Rust. Loose scale, thick scale, and thick rust shall be removed from the surfaces to be welded and within 25 mm [1 in] of the weld. Welds may be made on surfaces that contain thin mill scale and rust if:

(1) the mill scale and rust can withstand vigorous hand wire brushing; and

(2) if the applicable weld quality requirements of this code can be met.

All mill scale shall be removed from the following:

(1) web-to-flange connections
(2) joint boundary of groove welds subject to calculated tensile stress

Limits on welding on scale and rust

More surface prep for welding

3.2.4.1 Surfaces to be welded, and surfaces adjacent to the weld, shall be cleaned to remove evident quantities of the following:

- Water
- Oil
- Grease
- Other hydrocarbon based materials

Welding on surfaces containing residual amounts of foreign materials is permitted providing the weld quality requirements of this code can be met.

3.2.4.2 Welds are permitted to be made on surfaces with anti-spatter compounds or protective coatings applied providing the weld quality requirements of this code can be met. Protective coatings are not permitted on web-to-flange connections or joints subject to calculated tensile stress.

- Anti-spatter compounds ok
- Paint ok except for
  - web-to-flange connections, and
  - joints subject to tension

Base metal repairs

3.2.3.7 For discontinuities over 25 mm [1 in] in length with depth found to be greater than 25 mm [1 in], discovered before welding by visual inspection of cut edges of base metal, or found in welded joints during examination by RT or UT, the following procedures should be observed:

3.2.6~~3~~.7(2) *last paragraph*

The discontinuity on the cut edge of the base metal shall be removed to a depth of 25 mm [1 in] below ~~beyond~~ its intersection with the surface by chipping, air carbon arc gouging, or grinding to form a groove cross section with a minimum groove radius (r) of 6 mm [1/4 in] and a minimum groove angle (α) of 20 degrees, and shall be blocked off by SMAW, FCAW-G or GMAW in at least four weld layers not exceeding 3 mm [1/8 in] in thickness per layer. The repair may be completed by SAW (except for active fluxes), SMAW, FCAW-G, or GMAW with normal restrictions on layer thickness and welding processes.

C-3.2.6~~3~~.7(2) Provided there is no weld discontinuity at the fusion line between the weld and the lamination, Types W and X have little or no effect on performance. Multiple ~~layers~~weld passes ~~of low hydrogen SMAW,~~ applied as thin layers not exceeding 3 mm [1/8 in], may be used for sealing off laminations from the primary weld. ~~SMAW filler metals historically have provided high toughness in the weld metal, and because of low penetration, the welding arc produces little gas at the weld/base metal interface.~~ Filler metals approved for use by this code have sufficient toughness and good compatibility at the weld interface.

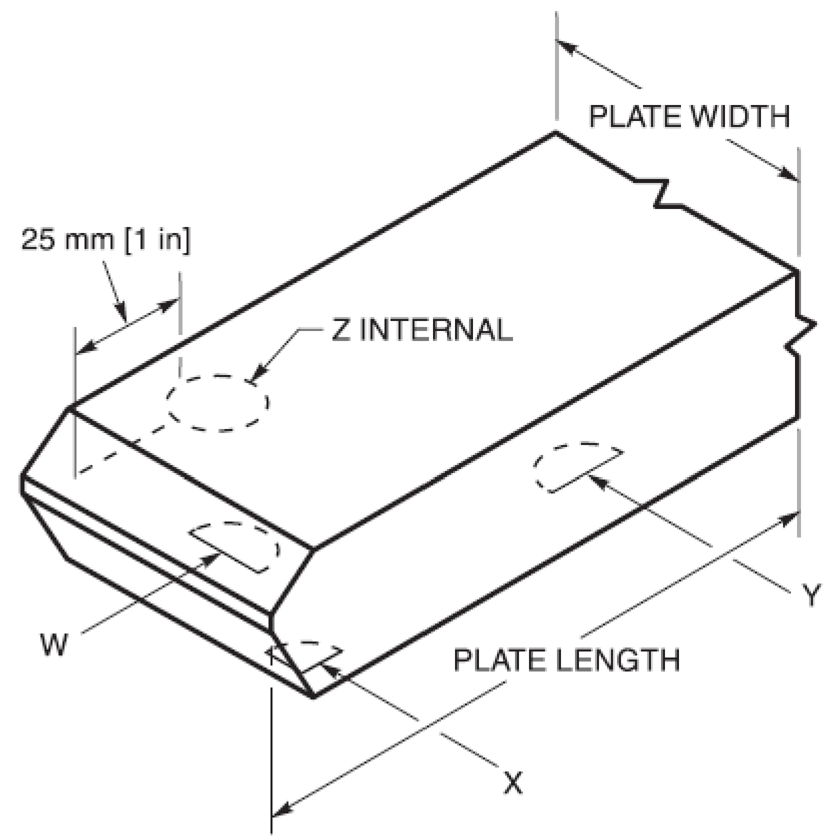


Figure 3.1—Discontinuities in Cut Plate (see 3.2.3.6)

Tack Welds

- Unless tack welds are remelted (as described in 3.3.7.3), they must
  - Meet Code requirements
  - Be done with in accordance with a WPS (including preheat)
  - Be cleaned and inspected before subsequent welding

3.3.7.1 All tack welds shall be subject to the same ~~quality~~ requirements as the final welds, ~~with the following exceptions:~~ except as exempted in 3.3.7.3. Tack welding shall be performed in accordance with a WPS meeting the requirements of Clause 3 unless exempted by 3.3.7.3. Tack welds shall be cleaned and visually inspected before subsequent welding.

C-3.3.7.1 This subclause requires that tack welds meet the same requirements as final welds, with a few exceptions as listed in 3.3.7.3. The exceptions deal with tack welds that are remelted. Tack welds that are not consumed in a final weld and are left in the structure require ~~remelted become part of the final weld and therefore~~ normal quality practices such as the removal of visible slag and/or cracks to ensure that they are sound prior to subsequent weld passes.

Fully Remelted and Incorporated Tack Welds

- Exemptions
  - No preheat required
  - Qualification testing not required
- Exemption requirements
  - Single pass
  - Table 4.1 filler metal
  - FCAW-S only over FCAW-S tacks
- Remelting Conditions
  - Macroetch verification, using
    - Max tax weld size
    - Minimum production weld heat input

3.3.7.3 Remelted Tack Welds. Tack Welds made in accordance with 3.3.7.3(1) and 3.3.7.3(2) shall be considered fully remelted and incorporated into the final weld and shall be exempt from the following requirements:

(a) Minimum preheat requirements shall not apply.

(b) WPSs for tack welding shall not require qualification testing in accordance with Clause 5.

(1) Exemption Requirements. The following conditions shall be met for the exemptions of 3.3.7.3 to apply:

(a) The tack welds shall be made in a single pass

(b) The filler metal for tack welding is listed in Table 4.1

(c) No other welding process may be used to weld over a FCAW-S tack weld unless qualified by 5.7.7.1.

(2) Remelting Conditions. To ensure that tack welds are fully remelted the following shall apply:

(a) The remelting capability of the subsequent welding process and procedure is verified by macroetch in accordance with Clause 5.18.2 and 5.19.3.

(b) The maximum tack weld size used in production shall not exceed the tack weld size used in the qualification testing.

(c) The heat input of the pass used to remelt the tack in production shall not be less than that used in the qualification testing.

C-3.3.7.3 Remelted tack welds are exempt from some code requirements because the remelting process eliminates the tack weld. The tack weld metal becomes part of the final weld metal. The code requirement to use Table 4.1 electrodes for tack welding is sufficient to ensure the quality of final welds that incorporate remelted tack welds.

Preheat is not required for remelted tack welds since the remelting process is expected to eliminate any potentially deleterious effects of welding on unpreheated steel, namely potentially hardened HAZs. However, even though preheat is not mandated for such tack welds, the tack welds must be crack-free in accordance with 3.3.7.5.

Given the restraint that tack welds resist, when tack welds do crack, the cracking is typically readily apparent. Visible inspection is generally sufficient assurance that no cracked tack welds are present before final welding. Cracked tack welds should not be confused with broken tack welds (see 3.3.7.5).

High heat input processes such as SAW and ESW typically remelt small, single pass tack welds. Other welding processes and procedures can also remelt small tack welds. However, processes that utilize lower levels of heat input, including some SAW procedures, may not remelt tack welds. The code provides a qualification method to ensure that the final welding process and procedure being used will effectively remelt the tack weld.

Unincorporated tack welds

- Removed
- Repair cracked base metal

3.3.7.4 Unincorporated Tack Welds.

(1) Removal. Tack welds that are not incorporated into the final weld shall be removed in such a manner that the base metal is not damaged. Base metal damaged during tack weld removal may be repaired when approved by the Engineer. If the repair involves welding, it shall be done in conformance with 3.7.1.

(2) Cracked Base Metal. The removal of tack welds may expose cracked base metal. When cracked base metal is discovered after tack welds are removed, all other tack weld removal locations in the tension regions on the member shall be tested by MT to assure that no cracks are present. If the MT testing reveals cracks, hardness testing of the HAZ shall be required. Hardness values shall not exceed Rockwell C30 in the HAZ. These excessively hard HAZs shall be removed by shallow grinding.

C-3.3.7.4 Unincorporated tack welds are usually avoidable, but when they are necessary, they are removed after welding to avoid local stress risers and to reflect sound workmanship. They can simply be ground away.

Depending upon the constraint conditions and size of the components being tacked, it is possible for cracking to occur; when such cracking is observed, the code requires that additional testing be conducted. However, the MT testing and hardness testing prescribed by the code are only required when cracking is observed; these tests are not required for tack weld removal sites that reveal no cracks.

Broken Tack Welds

- May stay in place if they break after welding has begun
- Not to be confused with cracked tack welds

3.3.7.5 Broken Tack Welds.

(1) General. If a tack weld breaks before welding of the joint has begun, the broken tack weld shall be removed, and if necessary, replaced.

(2) Exemptions. Tack welds that meet the requirements of 3.3.7.3 need not be repaired if the tack breaks after welding on that particular joint has begun.

~~3.3.7.5 Tack welding of steel backing should be done within the joint so that all tack welds will be remelted and incorporated within the final weld.~~

C-3.3.7.5 The code makes a distinction between "cracked tack welds" and "broken tack welds." Tack welds that fracture because of self-restraint and residual stresses are said to be "cracked." Tack welds that sever because of handling loads or thermal expansion that occurs during subsequent welding are said to have "broken."

Tack welds are usually small and may break during fabrication due to overstress from local restraint conditions. Broken tack welds can be repaired or removed if they break prior to final welding operations. However, tack welds may break ahead of an advancing welding arc due to thermal expansion due to welding and preheating. If final welding of a specific joint is already underway, it is more deleterious to stop final welding and repair the tack weld than to simply weld over it, so this practice is allowed.

Conversely, cracked tack welds should not simply be welded over. Broken tack welds that break during welding have cracks that are typically normal to the direction of applied load/restraint, and are easily distinguished from cracked tack welds, which occur before final welding and have cracks fractures with more unpredictable orientation.

Tack Welding of Backing

- Tack in the joint where practicable
- When not in the joint, make continuous unless you remove them

3.3.7.6 Tack Welding of Backing.

(1) Tack Welding within the Joint. Tack welding of steel backing shall, where practicable, be done within the joint so that all tack welds will be incorporated into the final weld.

(2) Tack Welding Outside of the Joint. Tack welds used to attach steel backing and placed external to the weld joint shall be made continuous by fillet welding for the full length of the backing, or shall be removed by grinding, at the Contractor's option.

C-3.3.7.6(2) Intermittent welds that attach longitudinal backing to the steel, made outside the joint, can be problematic under fatigue loading. Hence, the code provides two options for attaching backing: it may be with tack welds made in the joint (where they will be incorporated into the final weld), or it may be attached by fillet welds outside the joint, but such welds are required by the code to be continuous. Note that the preheat, qualification, and quality exemptions of 3.3.7.3 do not apply to these external tack welds.

Extend of preheat

- New commentary (changed Code in the 2015 edition)

4.2.~~2~~1.1 Extent of Preheat. Preheat temperature shall be maintained during the welding operation for a distance at least equal to the thickness of the thickest welded part, but not less than 75 mm [3 in] in all directions from the edge of the weld joint, measured at the location of the welding arc.

C-4.2.1.1 The code reflects that preheat must be present, at a minimum, within 75 mm [3 in] of the point of welding, but that it is not necessary to preheat the entire length of the joint before welding begins. For a shorter weld, such as a butt splice on a narrow flange, the fabricator may choose to achieve preheat for the full length of the joint before welding starts. For longer welds, such as web to flange fillet welds, the fabricator may choose to preheat locally as welding proceeds.

Though maximum interpass temperature is measured relatively close to the weld (see 4.2.2), minimum preheat temperature and minimum interpass temperature are measured at least 75 mm [3 in] from the edge of the weld joint to better ensure that the entire volume adjacent to the weld will be at or above the minimum preheat and minimum interpass temperature.

5.4.1 Base- Metal Qualification Requirements. For qualification of WPSs for approved base metals listed in 1.2.2, Tthe production base metals qualified by the PQR filler metal, base metal, and backing used in the qualification test shall conform to the following:Table 5.X, which lists the base materials that may be used in the test for a given production filler metal and base metal.

Equivalent ASTM steels shall be permitted for use as qualification test plates in accordance with Table 5.Y.

[see new tables 5.X and 5.Y below]

PQR Test Plate Specification and Grade	Qualified Production Base Metal Specification and Grade
M 270M/M 270 (A 709/A 709M) Gr. 250 [Gr. 36]	M 270M/M 270 (A 709/A 709M) Gr. 250 [Gr. 36]
M 270M/M 270 (A 709/A 709M) Gr. 345 [Gr. 50]	M 270M/M 270 (A 709/A 709M) Gr. 250, 345, 345S [Gr. 36, 50, 50S]
M 270M/M 270 (A 709/A 709M) Gr. 345W [Gr. 50W] (meeting requirements of 5.4.2)	M 270M/M 270 (A 709/A 709M) Gr. 250, 345, 345S, 345W, HPS 345W [Gr. 36, 50, 50S, 50W, HPS 50W]
M 270M/M 270 (A 709/A 709M) Gr. HPS 345W [Gr. HPS 50W]	M 270M/M 270 (A 709/A 709M) HPS 345W [Gr. HPS 50W]
Any steel with minimum specified yield strength >345 MPa [50 ksi]	PQR Test Plate Specification and Grade

Table 5.X. Base Metal Options for WPS Qualification Test Plates, [AASHTO M 270M/M 270 (ASTM A709/A709M) Grades (see 5.4.1 and C-5.4.1)]

	Base Metal Grade to be listed on WPS			
Filler Metal Strength to be listed on WPS MPa [ksi]	**Gr. 250 [36]**	**Gr. 345, 345S, 345W, HPS 345W [50, 50S, 50W, HPS 50W]**	**Gr. HPS 485W [HPS 70W]**	**Gr. HPS 690W [HPS 100W]**
415 [60]	Gr. 250 [36], or 345 [50], or 345W [50W], or HPS 345W [HPS 50W]	Gr. 250 [36], or 345 [50], or 345W [50W], or HPS 345W [HPS 50W]	Gr. 250 [36], or 345 [50], or 345W [50W], or HPS 345W [HPS 50W]	Gr. 250 [36], or 345 [50], or 345W [50W], or HPS 345W [HPS 50W]
485 [70] or 550 [80]	--	Gr. 345 [50] 345W [50W] HPS 345W [HPS 50W]	Gr. 345 [50] 345W [50W] HPS 345W [HPS 50W]	Gr. 345 [50] 345W [50W] HPS 345W [HPS 50W]
620 [90]	--	--	Gr. HPS 485W [HPS 70W]	Gr. HPS 485W [HPS 70W]
690 [100] or 760 [110]	--	--	--	Gr. HPS 690W [HPS 100W]

Table 5.Y

AASHTO M 270M/M 270 (A709/A709M) Grade	ASTM equivalent
Gr. 250 [36]	A36/A36M
Gr. 345 [50]	A572/A572M Gr. 345 [50]
Gr. 345W [50W]	A588/A588M, Gr. A or B

Base metals for WPS qualification testing

PAUT

- Testing of two joints
- 320 hours of experience

K4 Personnel Requirements

K4.1 Personnel Qualification Requirements. ~~Individuals who perform PAUT shall be qualified for PAUT per 6.1.3.4. In satisfying the requirements of 6.1.3.4, the qualification of the PAUT operator shall include a specific and practical examination that shall be based on the requirements of this code. This examination shall require the PAUT operator to demonstrate the ability to apply the rules of this code in the accurate detection and disposition of discontinuities.~~

Individuals who perform PAUT shall be certified for PAUT per 6.1.3.4. Additionally, individuals shall be certified as:

(a) UT Level II in accordance with 6.1.3.4(1) and have supplemental qualifications for PAUT; or

(b) UT Level III in accordance with 6.1.3.4(3) and have supplemental qualifications for PAUT. This includes Level III personnel who collect and analyze PAUT data.

Supplemental qualifications for PAUT shall include the following:

(1) A written test based on the PAUT requirements of this code

(2) PAUT examinations of at least two welded joints (e.g. butt, T, corner) that contain real or artificial flaws to be examined using a phased array procedure written in accordance with this Annex,

(3) 320 hours of PAUT work experience.

Individuals meeting the supplemental requirements except the work experience shall have data and reports reviewed and confirmed by a UT Level II with the supplemental PAUT qualifications or UT Level III with the supplemental PAUT qualifications.

C-K4.1 Personnel Qualification Requirements. These examinations evaluate the ability of PAUT personnel to apply the rules of this code in the accurate detection and disposition of discontinuities.

Bending

- Allowed without approval
  - Cold bending
  - Heat curving / bending
- Hot bending requires engineer approval

3.4.8 To achieve or restore the required geometry, elements may be aligned by:

(1) applied force causing yielding ("mechanical bending")

(2) methods that use controlled heating with restraint or support (including "heat shrink" or upset shortening)

(3) With Engineer approval, by a combination of controlled heating and mechanical means.

3.4.8.1 Elements to be heated shall be supported to minimize stress from gravity and external forces that would interfere with the desired results.

3.4.8.2 For any application of heat, the maximum temperature of the heated areas shall not exceed 600°C [1100°F] for M 270M/M 270 (A709/A709M) Grades HPS 485W [HPS 70W] and HPS 690W [HPS 100W] steels, or 650°C [1200°F] for the other steels listed in Table 4.1.

3.4.8.3 Accelerated cooling shall not be applied to steel above 315°C [600°F].

3.4.8.4 When mechanical means are used in combination with heat, the force shall not be initially applied or increased when steel temperature is either below 5°C [40°F] or between 150°C [300°F] and 370°C [700°F].

3.4.8.5 Mechanical forces shall be released before welding the element to other members.

C-3.4.8 All bending and straightening methods affect weld and base metal properties to some degree. Research on bridge repair indicates that the upset shortening method utilizing passive restraint has less effect on final steel properties than mechanical methods with or without the application of heat, but displacement produced by heat-assisted mechanical methods is more predictable and efficient.

Editions of the code prior to 2020 only permitted heat straightening of fracture critical members by the upset

3.7.3 ~~As approved by the Engineer, members~~ Members damaged or distorted beyond provisions of the distortion control plan ~~may be straightened by mechanical means or by carefully supervised application of a limited amount of localized heat. The temperature shall be~~ shall be corrected as described in 3.4.8.

12.12 Straightening, Curving, and Cambering

Straightening, curving, and cambering shall be in accordance with 3.7.3. ~~Cold bending shall be prohibited for all fracture critical steels. Bent and distorted material may be corrected prior to assembly and welding by approved upset shortening methods (heat straightening, curving and cambering).~~

Base Metals for WPS Qualification

- No separate testing for
  - Hybrid joints
  - Undermatched joints
- Material for backing moved

C-5.4.1 Base-Metal Qualification Requirements. The chemical composition of the steel used as test plates and steel backing can affect test results. Chemical elements obtained by pickup, also called dilution, from the base metal can affect hardness, strength, ductility, and toughness. However, the restriction of base metals to the grades of AASHTO M270 or ASTM A709 listed in 1.2.2 means that there will be no unexpected interactions between base metal and weld metal. Qualification to this code primarily tests the weld metal. ~~Steel for qualification test plates is selected to approximately~~ "match" the weld metal; therefore, there is no separate testing for undermatched or hybrid joints. The relationship between the qualification test and the base metal qualified for use in production is addressed in 5.19.3, which establishes that the mechanical testing results must be as appropriate for the base metal to be used in production. Matching filler metal WPSs are also governed by Table 4.1.

Table 5.X lists test plate materials that may be selected to qualify a WPS for a given combination of filler metal and base metal. The test plate material is not required to be the same material that will be used in production, as long as the qualification test meets the requirements of Table 5.1. For example, to qualify a WPS using Gr. 36 plate and E61T1 electrodes, it is permissible to use Gr. 50 base metal for the test plate. For a WPS using Gr. 50W plate and E8XT1 electrodes, it is also permissible to use Gr. 50 base metal for the test plate, but per 5.19.3.1 and Table 5.1, the required tensile strength would be 70 ksi. Clause 5.19.3.2 addresses how to use Table 5.1 when qualifying undermatched WPSs.

~~**5.4.5 WPS Backing.** Steel backing used in weld tests shall be of the same specification and grade as the weld test plates, but CVN tests shall not be required.~~

5.19.34 Reduced-Section Tension, All-Weld-Metal Tension, and CVN Tests.

5.19.3.1 Matching Strength. For qualifying WPSs with matching strength filler metal, ~~T~~the mechanical properties shall conform to the values specified in Table 5.1 for the base metal listed on the WPS~~, or as described in contract documents~~.

5.19.3.2 Undermatching. For qualifying WPSs with undermatching filler metal, the mechanical properties shall conform to the values specified in Table 5.1 for the base metal grade used for the qualification test (see Table 5.X).

C-5.19.3.2 Undermatching. In code editions prior to 2020, qualification testing for WPSs using undermatched filler metal was required to be performed using the base metal listed on the WPS, and the WPS qualification was exempted from reduced-section tension and bend tests. In 2020, the qualification requirements were modified to require test plate base materials to be chosen to approximately match the strength of the filler metal; the base metal will not be the same material as will be used in production.

This allows bend testing and reduced-section tensile testing of the sample weld. Because the undermatched weld metal will not match the strength of the production base metal, the WPS base metal is not the same as that used in the qualification test. Table 5.1 is used to determine the required properties as a function of the base metal used in the test.

QA and QC

- Some clarifications in 2020
- Look to align with D1.1 in next edition (i.e., use "verification")?

6.1.1 For the purpose of this code, quality control (QC) functions ~~inspection and testing and~~ are performed by the Contractor and quality assurance (QA) ~~inspection and testing~~ functions are performed by the Owner. They shall be considered separate functions.

C-6.1.1 "For the purposes of this code" limits these definitions to inspection of bridge fabrication under this code. These provisions delegate responsibilities for inspection to the Contractor/ Fabricator/ Erector for assuring the quality of work performed is in conformance with the contract documents, and to the Owner for the accuracy of the contract documents and providing applicable guidance and oversight to the Contractor. This does not define the overall Quality Management Program or prohibit Contractors from performing QA functions as a part of their Quality Program. In AWS D1.1, QC is termed fabrication/erection inspection and QA is termed verification inspection.

~~C-6.1.1 The intent of these provisions is to clearly separate responsibilities for inspection. The Contractor/Fabricator/Erector is responsible for the quality of the work to be performed in conformance with the provisions of the contract documents. The Owner is responsible for the accuracy of the contract documents and for payment for acceptable work as specified in the contract. QC is termed fabrication/erection inspection in AWS D1.1, and QA is termed verification inspection.~~

NDE

6.7.4. Fillet Welds and PJP Groove Welds. Requirements for 10% testing given in Table 6.X shall be satsified by 6.7.4.1 or 6.7.4.2, as applicable.

~~6.7.2.1~~ **6.7.4.1 Long Welds.** For welds 3 m [10 ft] or longer, at least 300 mm [12 in] shall be tested in every 3 m [10 ft] length. ~~including longitudinal welds in butt joints in beam or~~

6.7.4.2 Short Welds. Welds less than 3 m [10 ft] in length shall be tested on either a per-joint or per-lot basis in accordance with either 6.7.4.2(1) or 6.7.4.2(2), respectively.

(1) Testing on Per-Joint Basis. At least 300 mm [12 in] of each weld shall be tested. If a defect is found in any test length, the full length shall be tested.

(2) Testing on Lot Basis. 10% of the total joints in a lot as defined in 6.7.1 shall be tested for their full length. Joints tested on a lot basis shall be distributed throughout the work and shall total at least 10% of the applicable fillet weld or PJP weld length. If defects are found in 20% or more of the joints tested in a lot, all joints in that lot shall be tested for their full length.

C-Table 6.X The NDT acceptance criteria are workmanship standards and not based on fitness for purpose. The criteria reflect the level of workmanship that can be expected in a bridge shop.

The AASHTO LRFD Bridge Design Specifications define main or primary members. Typical fillet or PJP groove welds that require testing are any welds to web or flange, and welds connecting components of cross frames or diaphragms for curved bridges. Typical joints in compression or shear include web-to-flange welds, stiffeners to webs or flanges, and lap joints.

Table 6.X *(new table)*
NDT Methods and Frequency

Weld Type	Joint Type	Process	Member Design Stress Type	NDT Method	Frequency
CJP groove welds	Butt joints other than in webs of flexural members	Other than ESW or EGW	Tension or reversal	RT	100% of each joint
			Compression or shear	UT or RT	25% (See 6.7.3)
		ESW or EGW	Tension or reversal	RT and UT	100% of each joint
			Compression or shear		25% (See 6.7.3)
	Butt joints in webs of flexural members, transverse to the direction of bending stress	Other than ESW or EGW	Tension	RT	1/6 of the web depth beginning at the tension flange or flanges for each joint
		ESW or EGW		RT and UT	
		Other than ESW or EGW	Compression	UT or RT	25% of the remainder of the web depth for each joint
		ESW or EGW		RT and UT	
	Butt joints in webs of flexural members, parallel to the direction of bending stress	Other than ESW or EGW	Shear	UT or RT	25% (See 6.7.3)
		ESW or EGW		RT and UT	
	T- or corner joints	Any	Tension or reversal	UT	100% of each joint
			Compression or shear (including web to either flange)		25% (See 6.7.3)
PJP groove welds and fillet welds, Grade HPS 690W [HPS 100W]	Any	Any	Any	MT	100% of each joint
PJP groove welds and fillet welds, all other grades					10% (See 6.7.4)

Various

- 1.7 Safety precautions
  - Have avoided prescriptions; now adopting AWS boiler plate
- 4.20 Requirement that flux be "fused" is removed
- 5.5.1 Consumable manufacture or consumable name can change without necessity of running qualification tests again
- Digital RT allowed (DR or CR); monitor provided
- 7.7.5 - Repair of base metals when studs fail
  - For tension components, fair material for if 98% of section remains; otherwise weld and finish
  - For compression components, no repair needed
- 12.2.2 FCM – Definition of "fracture critical" adopted from AASHTO
- d

New Clause 2: Normative References (was Annex P and *Informative* in 2015)

New Clause 3: Terms and Definitions (was Annex D and *Normative* in 2015)

Annex P and Annex D will be deleted once the language is moved to Clause 2 and Clause 3.

On the horizon

- Addition of 50CR
  - With hybrid joints…?
- Addition of tubular materials
- Fracture Critical changes
  - Addition of SRM / IRM language (structurally redundant members / internally redundant members)
  - Retirement of FC…?
- PAUT updates
  - Alignment with D1.1
  - Changes from NCHRP 14-37 (Report 908)
    - Acceptance criteria?
    - Calibration (applies to traditional UT as well)
    - Personnel qualifications (may also apply to traditional UT)
- Deletion of fabrication requirements when new fab spec is ready