WASHINGTON ASSOCIATION OF BUILDING OFFICIALS
WELDER PROGRAM

WABO
WELDER AND WELDING OPERATOR PERFORMANCE QUALIFICATION STANDARD
FOR

- STRUCTURAL STEEL
- SHEET STEEL
- REINFORCING STEEL
- SEISMIC RESTRICTED ACCESS

WABO Standard No. 27-13
Twelfth Edition **Effective June 2023**

FOREWARD

This twelfth edition of the *Welder and Welding Operator Performance Qualification Standard* No. 27-13 updates and replaces previous editions of this Standard and reflects the applicable requirements and intent of most recent editions of the *Washington State Building Code; Structural Welding Code-Steel (ANSI/AWS D1.1); Structural Welding Code – Seismic Supplement (ANSI/AWS D1.8); Structural Welding Code-Sheet Steel (ANSI/AWS D1.3)* and the *Structural Welding Code-Reinforcing Steel (ANSI/AWS D1.4).*

This Standard has been compiled through the joint efforts of members of the Washington Association of Building Officials (WABO) and members of the American Welding Society (AWS).

Acknowledgements:

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PREFACE

The Washington Association of Building Officials (WABO) is a nonprofit corporation established to research, develop, and promote the uniform implementation and enforcement of building codes in the State of Washington. The Association's membership includes building officials from jurisdictions at all levels (state, county, city, and town) who are responsible for administering and enforcing building codes.

Building codes adopted within the State of Washington include requirements for qualifications of welders. To provide greater confidence in compliance with these requirements, WABO Standard 27-13 establishes uniform qualification and testing procedures for certification of welders, welding operators, and tackers.

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SECTION 27-13.1 – PURPOSE

The purpose of this Standard is to provide greater confidence to design professionals, owners, and building officials that welders, welding operators, and tackers are qualified to perform the work for which they have been certified for building construction.

Certification of personnel in accordance with this Standard is intended to be part of an overall welding quality assurance program. Other components of welding quality assurance may include but are not limited to the following:

- Approved construction documents
- Contractor quality control
- Approved welding procedures
- Welder qualifications not covered by this Standard
- Material testing
- Building department inspections
- Special inspections
- Structural observation

The qualification tests described in this Standard are not intended to be used as a guide for welding during actual construction, and certification of personnel in accordance with this Standard shall not be used as a substitute for other requirements of welding quality assurance.

SECTION 27-13.2 – SCOPE

The provisions of this Standard shall apply to the qualification and certification of welders, welding operators and tackers performing structural steel, sheet steel, seismic, and reinforcing steel welding. The limitations of welder and welding operator qualifications are found in Table 27-13-I.

SECTION 27-13.3 – WELDER QUALIFYING AGENCY REQUIREMENTS

1. GENERAL

Only WABO Approved Welder Examiners employed at WABO Welder Qualifying Agencies are authorized to perform the welder and welding operator performance qualification tests required by this Standard at WABO approved facilities.

Welder Qualifying Agencies interested in becoming approved by WABO to perform the tests may obtain application forms and information concerning certification by contacting the WABO office or by visiting the WABO website at www.wabo.org.

2. ELIGIBILITY

The following organizations are eligible to become approved WABO Welder Qualifying Agencies:

2.1 Independent testing laboratories
2.2 Private and public welder vocational training institutions, including those operated by labor unions
2.3 Steel fabricator plants certified by the AISC Quality Certification Program
2.4 Others granted approval by WABO

3. INSPECTION-EVALUATION

Inspection-Evaluation of welder qualifying agencies will be performed by one or more persons selected by WABO who are knowledgeable in welding and welder qualification. The agency will receive a technical survey of its testing facility and methods of record keeping.

4. CERTIFICATION OF WELDER QUALIFYING AGENCIES

Upon recommendation for certification by the Inspection-Evaluation team, WABO will issue certificates identifying the agency and its key personnel. The agency certificate will be valid for a three-year period, subject to periodic re-inspections of the agency.

5. AGENCY PERSONNEL

Agency personnel witnessing the tests and approving the mechanical and visual test coupons must be WABO Approved Welder Examiners. Agency personnel can become WABO Approved Welder Examiners by submitting proof that they are an AWS Certified Welding Inspector (CWI) qualified and certified in accordance with the provisions of AWS QCI, Standard for Qualification and Certification of Welding Inspectors and successfully completing the WABO written Welder Examiner Test based on the contents of this Standard. Upon successful completion of the written exam, an Approved Welder Examiner card will be issued. Examiner cards are valid for one year and are required to be renewed annually.

Personnel performing radiographic testing will be qualified in accordance with the current edition of the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A. Only individuals qualified for NDT Level II may perform and interpret radiographic testing.

SECTION 27-13.4 – WELDER CERTIFICATION

Welders and welding operators may become certified by WABO in one or more of the following categories and processes by satisfactory completion of the applicable qualification tests described in this Standard.

Following are the welder certification classifications available through the WABO Welder Certification Program.

1. STRUCTURAL WELDER

PROCESS	METHOD
Shielded Metal Arc Welding (SMAW)	Manual
Gas Tungsten Arc Welding (GTAW)	Manual
Gas Metal Arc Welding (GMAW)	Semi-Automatic
Flux Core Arc Welding (FCAW)	Semi-Automatic

2. SHEET STEEL WELDER

PROCESS	METHOD
Shielded Metal Arc Welding (SMAW)	Manual
Gas Tungsten Arc Welding (GTAW)	Manual
Gas Metal Arc Welding (GMAW)	Semi-Automatic
Flux Core Arc Welding (FCAW)	Semi-Automatic

3. WELDING OPERATOR

PROCESS	METHOD
Submerged Arc Welding	Semi-Automatic

4. REINFORCING STEEL WELDER

PROCESS	METHOD
Shielded Metal Arc Welding (SMAW)	Manual
Gas Metal Arc Welding (GMAW)	Semi-Automatic
Flux Core Arc Welding (FCAW)	Semi-Automatic

5. SEISMIC RESTRICTED ACCESS WELDER
(PREREQUISITE: WABO Certification for Field Structural Welder in applicable process)

PROCESS	METHOD
Shielded Metal Arc Welding (SMAW)	Manual
Flux Core Arc Welding (FCAW)	Semi-Automatic

6. WELDER CERTIFICATION CARDS

6.1 Welder certification cards are the property of WABO and issued to the certified welder to keep in their possession for a period of one year. For certifications to remain valid, the welder must have the certificate endorsed by his/her supervisor or designee, or by a WABO Approved Welding Examiner. The endorser shall have witnessed the individual's welding during the calendar quarter being endorsed.

6.2 To renew the certification, the welder shall submit properly endorsed signature form to WABO and pay a renewal fee.

6.3 The qualification of the welder or welding operator shall remain in effect indefinitely unless:

6.3.1 The welder or welding operator is not engaged in the weld process for which he/she is qualified for a period exceeding six (6) months, in which case a new qualification test shall be required.

6.3.2 There is some specific reason to question a welder or welding operator's ability, in which case, a new qualification test may be required. In the event the welder or welding operator fails to pass the new qualification test, certification shall be suspended until he/she can successfully complete the welding test.

6.3.3 The welder fails to renew his/her certification on or before the expiration date. **EXCEPTION:** An expired certification may be reinstated within sixty (60) days after the expiration date. Thereafter, a new qualification test shall be required.

6.3.4 Certification for Seismic Restricted Access Welder shall remain valid for 36 months, providing the continuity requirements for process use outlined above are met. After 36 months a new qualification test is required.

6.4 WELDER CERTIFICATION REVOCATION

Each certification card carries the statement "This card is the property of WABO," which entitles all possession rights to WABO, thereby extending authority beyond the officers, executive board and program managers to any representative acting on behalf of WABO, i.e. building officials, inspectors, and examiners to confiscate any certification card for probable cause. Confiscated certification cards must be forwarded to the WABO office, accompanied by a written explanation of circumstances, within five (5) working days of the infraction date.

Any Certificate issued by WABO for certification and registration programs presented as qualification by an individual:

6.4.1 Other than the certificate holder, for any reason, will deem any and all WABO certificates held by the certificate holder revoked for a period of not less than three (3) years from the date of infraction.

6.4.2 The person presenting another certificate holders certificate, for any reason, will also automatically have any and all WABO certificates revoked for a period of not less than three (3) years from the date of infraction.

6.4.3 If the person presenting another individual's certificate is not currently certified by WABO, that person will be prohibited from obtaining any WABO certification for a period of not less than three (3) years from the date of infraction.

6.4.4 Altered certificates, other than those approved and currently on file at WABO carry the same three (3) year revocation provision.

SECTION 27-13.5 – WELDER QUALIFICATION GENERAL REQUIREMENTS

1. KNOWLEDGE AND ABILITY

1.1 WORK PERFORMANCE

Each welder and welding operator shall perform one or more test welds on prepared test coupons in accordance with the following:

1.1.1 Welding machines shall be set at zero or minimum setting prior to the welder or welding operator adjusting the machine.

1.1.2 Prior to welding, each test weldment shall be identified by placing a welder or welding operator identification mark and laboratory test number on the test weldment for each process and position.

1.1.3 Each specimen removed from the test weldment shall be stamped with laboratory test number and specimen number.

1.1.4 Test weldments may not be removed from position during the test.

1.1.5 Cleaning and removal of slag, undercut and excess bead convexity between passes is acceptable if made in position with the approval of the Welder Examiner.

1.1.6 Grinding of root and cover passes not permitted.

1.1.6.1 Root pass grinding on pipe is acceptable with permission of the Welder Examiner.

2. RECORDS

A complete record shall be made of the tests performed by each welder or welding operator, and of the results of those tests.

Original copies shall be forwarded by the Welder Examiner to the WABO office within thirty (30) days, together with the application and processing fee.

A copy of each record shall be kept by the Welder Examiner, at the qualifying agency, for a period of three (3) years. Bend test specimens and radiographic specimens shall be retained by the Welder Examiner, at the qualifying agency, for a period of six (6) months. Copies of radiograph reports shall be forwarded to the WABO office with the original record. The original copies of the tests shall be kept for current welders at the WABO office indefinitely.

Certificates shall be issued by the WABO office. A roster of currently certified welders and welding operators shall be kept at the WABO office.

Records and specimens shall be available to those authorized by WABO to examine them. Visual specimens and bend specimens shall be maintained securely fastened together with identification stamping clearly visible.

SECTION 27-13.6 – WELDER QUALIFICATION TESTS

1. QUALIFICATION TEST FOR STRUCTURAL WELDERS

The welder qualification test for manual and semi-automatic welding shall be one of the following:

1.1 Groove weld test for plate of unlimited thickness.
1.2 Groove weld test for plate of limited thickness.
1.3 Groove weld test for butt joints on pipe or square or rectangular tubing of unlimited thickness.
1.4 Groove weld test for T-, K-, or Y-connections on pipe or tubing of unlimited thickness.

2. QUALIFICATION TEST FOR SHEET STEEL WELDERS (See Figure 27-13.09.7)

The welder qualification test for Sheet Steel welding shall be a fillet welded T-joint test (sheet to supporting member).

3. QUALIFICATION TEST FOR WELDING OPERATOR (See Figure 27-13.09.8)

The welding operator qualification test shall be a groove weld test on plate.

4. QUALIFICATION TEST FOR REINFORCING STEEL WELDERS (See Figure 27-13.09.9)

The welder qualification test for reinforcing steel welders shall be a flare bevel groove indirect butt joint.

5. SUPPLEMENTARY QUALIFICATION TEST FOR SEISMIC RESTRICTED ACCESS WELDER

5.1 GENERAL

This test is used to qualify welders for flat position groove welding. Back gouging is part of this test when steel backing is used and required to be removed. It is also used to qualify welders when non-steel backing is used, or when open root groove welds are used. WABO Certification for Field Structural Welding in applicable process is a prerequisite.

5.2 TEST PLATE CONFIGURATION

The test plate configurations and dimensions shall be as shown in Figure 27-13.14.1 or Figure 27-13.14.2, and Figure 27-13.14.3 as applicable.

5.3 TEST PLATE FABRICATION

5.3.1 GENERAL REQUIREMENTS

5.3.1.1 TEST PLATE ASSEMBLY

The parts for the test plate assembly may be cut and tack welded together by an individual other than the welder performing the qualifications test, except that the welder being qualified shall attach the required weld tabs.

5.3.1.2 WELDING PROCEDURE SPECIFICATION

The test plate assembly shall be welded in accordance with a WPS using the process for which the welder is being qualified. The combination of variables shall be such that the deposition rate used in the qualification test is equal to or greater than the highest deposition rate that will be used in production.

5.3.2 ADDITIONAL REQUIREMENTS FOR OPTION A

Option A shall be used to qualify welders to use steel backing.

5.3.2.1 STEEL BACKING

The steel backing shall be a minimum thickness of 1/4 in. (6 mm), and a maximum of 3/4 in. (18 mm), and shall be at least 1 in. (25 mm) wide. Backing width should be at 3 in. wide if radiography will be used to evaluate weld. The backing shall be attached to the test plate assembly with tack welds.

5.3.2.2 GROOVE WELD DETAIL

The groove weld detail shall use a 3/8 in. (6 mm) root opening, +/- 1/16 in. (1.5 mm). The included angle shall be 30 degrees, +/- 5 degrees.

5.3.3 OPTION A LIMITATIONS

Welders qualified in accordance to Option A shall be permitted to weld on any joint that uses steel backing. Separate qualification shall be required if the type of backing is changed (e.g., a change from steel to ceramic, or from steel backing to open root joints, etc.).

5.3.4 ADDITIONAL REQUIREMENTS FOR OPTION B

Option B shall be used to qualify welders for the use of other than steel backing, including the use of ceramic or copper backing, or open root welding.

5.3.5 BACKING REMOVAL

After the groove weld has been completed, the non-steel backing (if used) shall be removed by the welder being qualified.

5.3.6 BACK GOUGING AND BACK WELDING

Removal shall be done in the overhead position. The root of the weld shall be back gouged to sound metal. The back gouged cavity shall be back welded. The back welding shall be performed in the overhead position. The welding process for the overhead welding need not be the same as that used for the flat position welding. The depth of the back gouging shall not exceed 1/4” (6 mm).

5.3.7 OPTION B LIMITATIONS

Welders qualified in accordance to Option B shall be qualified to use the specific backing type used during the test. Root openings shall be no greater than that used in the welder qualification test. Separate qualifications shall be required if the type of backing is changed (e.g., a change from copper to ceramic, or copper to steel, etc.).

5.4 SPECIMEN TESTING

5.4.1 VISUAL INSPECTION

After removal of the web plate, column plate and attachment plate, the weldment shall be visually inspected.

5.4.2 ADDITIONAL TESTING

The test plate shall be subject to one of the following tests, at the option of the WABO Examiner:

(1) Bend tests (See Section 27-13.11.7)
(2) RT inspection

5.4.2.1 BEND TESTS

5.4.2.1.1 SPECIMEN LOCATIONS

The flat test plate shall be cut to prepare four transverse side-bend tests, with each test sample 3/8 inch (10 mm) thick. Two side-bend specimens shall be from the region that was under the 1 inch (25 mm) web plate. Two side bends shall be taken from within 1/4 inch (6 mm) of the ends of the welds. The side of the specimen nearest to the end of the weld shall be clearly marked.

5.4.2.1.2 SPECIMEN TESTING PROCEDURE

For the two specimens taken from the ends of the weld, the specimens shall be bent so that the side of the bend specimen that was nearest to the end of the weld becomes the convex side of the bend specimen (e.g., sees the greatest tension).

6. RETEST

In case a welder or welding operator fails to meet the requirements of one or more test welds, a retest may be allowed under the following conditions:

6.1 An immediate retest within seven (7) days of notification of failure. The retest shall consist of two test welds of each type in each position on which the welder or welding operator failed.

6.2 A subsequent retest may be made provided the welder or welding operator submits documented proof of eight (8) hours minimum further training or practice, in which case a single retest weld of each type and position failed shall be made.

SECTION 27-13.7 – QUALIFICATION TESTS REQUIRED AND LIMITATIONS

1. GENERAL NOTES

Field qualification qualifies for shop, but shop qualification does not qualify for field.

Qualified thickness range and positions are shown on Tables 27-13-A through H. The limitations of these certifications are shown on Table 27-13-I.

A welding operator qualified with an approved electrode and shielding medium combination shall be considered qualified to weld with any other approved electrode and shielding medium combination for the process used in the procedure qualification test.

For structural and reinforced steel qualifications, vertical position welding progression shall be upwards.

For each weld process (SMAW, GMAW, FCAW, GTAW, SAW) for which certification is required, test plates or pipe shall be welded using any of the structural steels listed in Table 27-13-J using the electrodes, positions and plate or pipe thicknesses in Tables 27-13-A through E.

For sheet steel welder qualifications, T-joint test plates shall be welded using one of the sheet steels listed in Table 27-13-K using electrodes and positions shown in Tables 27-13-F and 27-13-G. For SMAW, GMAW, and FCAW, Sheet Steel qualification test qualifies welder for both galvanized and uncoated steel. For GTAW, the Sheet Steel Qualification test qualifies the welder for uncoated steel only.

For reinforcing steel welder qualifications No. 4 ASTM A706 bars shall be welded to any of the structural steels listed in Table 27-13-J with the electrodes and in the positions shown on Table 27-13-H. Two (2) test assemblies are required.

The welder shall be certified for the welding process and method used in qualification tests only (SMAW, GMAW, GTAW, FCAW, and SAW). Certifications for all others are not covered by this Standard.

Welder shall be qualified to weld all filler metals of the same designation and lower strength than that used in the test (F4 and lower for SMAW process). See Table 27-13-L.

Upgrading from shop to field certifications do not need to be administered by the same examiner or the same WABO testing agency.

SECTION 27-13.8 – VISUAL INSPECTION CRITERIA FOR ACCEPTANCE

All welds shall be visually inspected. The root pass shall be visually inspected and approved by the WABO Approved Welder Examiner prior to continuation. Final visual inspection of welds may begin immediately after the completed welds have cooled to ambient temperature.

1. PLATE AND REINFORCING STEEL WELDS

A weld shall be acceptable by visual inspection if it shows the following:

- **1.1** The weld has no cracks or arc strikes outside the weld area.
- **1.2** Thorough fusion exists between adjacent layers of weld metal and between weld metal and base metal.
- **1.3** All craters are filled to the full cross section of the weld.
- **1.4** Weld profiles are in accordance with Section 27-13.8.4.
- **1.5** Undercut shall not exceed 1/32" deep.
- **1.6** The piping porosity does not exceed one pore.
- **1.7** Welds are started and terminated at the end of a joint in a manner that will insure sound welds.

2. TUBULAR WELDS

A tubular weld shall be acceptable by visual inspection if it shows the following:

- **2.1** The weld has no cracks or arc strikes outside the weld area.
- **2.2** All craters are filled to the full cross section of the weld.
- **2.3** The face of the weld is at least flush with the outside surface of the pipe, and the weld is merged smoothly with the base metal. Undercut shall not exceed 1/32" and weld reinforcement shall not exceed the following:

PIPE WALL THICKNESS (Inches)	REINFORCEMENT MAXIMUM (Inches)
3/8 or less	3/32
3/8 to 3/4 incl.	1/8
Over 3/4	3/16

2.4 There is no evidence of cracks, incomplete fusion, or inadequate joint penetration in the root. A concave root surface is permitted, within the limits of Section 27-13.8.2.2.5, below, provided the total weld thickness is equal to or greater than that of the base metal.

2.5 The maximum root surface concavity is 1/16 ", and the maximum melt-through is 1/8 inch.

3. SHEET STEEL FILLET WELDS

A fillet weld shall be acceptable by visual inspection if it is reasonably uniform in appearance and is free of overlap, cracks, and excessive undercut.

4. ACCEPTABLE AND UNACCEPTABLE WELD PROFILES

Groove welds shall preferably be made with slight or minimum reinforcement. The reinforcement shall not exceed 1/8 inch in height and shall have gradual transition to the plane of the base metal surface (see Figure 27-13.10.1). Welds shall be free of the discontinuities shown for butt joints (See Figure 27-13.10.2).

SECTION 27-13.9 – TEST SPECIMENS, ROOT-, FACE-, OR SIDE-BEND

1. TYPE AND NUMBER

The type and number of test specimens that must be mechanically tested to qualify a welder when radiographic testing is not used are shown in Figures 27-13-11.1 through 11.9.

SECTION 27-13.10 – METHODS OF TESTING SPECIMENS

1. ROOT-, FACE-, OR SIDE-BEND TEST AND EVALUATION

The entire length of the groove weld shall be examined visually prior to cutting specimens.

Each specimen shall be bent in a jig having the contour shown in Figure 27-13-12.1 and otherwise substantially in accordance with that Figure. Any convenient means may be used to move the plunger member with relation to the die member.

The specimen shall be placed on the die member of the jig with the weld at midspan.

Root-bend specimens shall be placed with the root of the weld directed toward the die member.

Face-bend specimens shall be placed with the face of the weld directed toward the die member.

Side-bend specimens shall be placed with that side showing the greater discontinuity, if any, directed toward the die member.

The plunger member shall force the specimen into the die member until the specimen becomes U-shaped. The weld and heat-affected zones shall be centered and completely within the bent portion of the specimen after testing.

The convex surface of the bend test specimen shall be visually examined for surface discontinuities. For acceptance, the surface shall contain no discontinuities exceeding the following dimensions:

1.1 1/8 inch - measured in any direction on the surface

1.2 3/8 inch - the sum of the greatest dimensions of all discontinuities exceeding 1/32 inch, but less than or equal to 1/8 inch

1.3 1/4 inch - the maximum corner crack, except when that corner crack resulted from visible slag inclusion or other fusion type discontinuities, then the 1/8 inch maximum shall apply. Specimens with corner cracks exceeding 1/4 inch with no evidence of slag inclusions or other fusion type discontinuities shall be disregarded, and a replacement test specimen from the original weldment shall be tested

2. SHEET STEEL FILLET WELD BREAK TEST AND EVALUATION

The entire length of the fillet weld (see Figure 27-13-12.2) shall be examined visually and then the 5 inch long specimen shall be loaded in such a way that the root of the weld is in tension. The load shall be steadily increased or repeated until the specimen fractures, or bends flat upon itself.

The specimen shall pass the test if it bends flat upon itself or, if the fillet weld fractures, the fractured surface shows complete fusion to the root of the joint.

3. REINFORCING STEEL WELD TEST AND EVALUATION

The entire length of the flare bevel groove welds shall be visually examined. Then each test assembly shall be mechanically cut at two locations to provide two transverse cross sections of each weld assembly.

A macrotech test shall be performed by polishing and etching cross sections with a suitable solution to give a clear definition of the weld. The etched cross section shall show the minimum designated effective weld size (E = 0.10” for No. 4 bar) for the flare groove test assemblies. (See Figure 27-13.09.9)

4. RADIOGRAPHIC TESTING

Radiographic examination of the welder or welding operator test plate may be made in lieu of a bend test.

If radiographic testing is used in lieu of the prescribed bend tests, the weld reinforcement need not be ground or otherwise smoothed for inspection unless its surface irregularities or juncture with the base metal would cause objectionable weld discontinuities to be obscured in the radiograph. If the backing is removed for radiography, the root shall be ground flush with the base metal.

Exclude 1-1/4 inch at each end of the weld from evaluation in the plate test for welder qualification and exclude three (3) inches at each end of the length of the test plate for welding operator qualification.

Welded test pipe shall be examined for a minimum of one-half of the weld perimeter selected to include a sample of all positions welded. (For example, a test pipe or tube welded in the 5G, 6G or 6GR position shall be radiographed from the top center line to the bottom center line on either side.)

The radiographic procedure and technique shall be in accordance with the current requirements of ANSI/AWS D1.1.

For acceptable qualification by the radiograph, the weld shall have no cracks and shall conform to the following:

4.1 The greatest dimension of any porosity or fusion-type discontinuity that is 1/16 inch or larger in greatest dimension shall not exceed size (B), indicated in Figure 27-13-13.1 for the effective throat or weld size involved. The distance from any porosity or fusion-type discontinuity described above to another such discontinuity shall not be less than the minimum clearance allowed (C) indicated in Figure 27-13-13.1 for the size of discontinuity under examination.

4.2 Discontinuities having a greatest dimension of less than 1/16 inch shall be unacceptable if the sum of their greatest dimension exceeds 3/8 inch in any linear inch of weld.

SECTION 27-13.11 – TECHNICAL INQUIRIES

All inquiries must be submitted in writing to:

Welding Performance Standard Technical Advisory Task Force
WABO
PO Box 7310
Olympia WA 98507-7310

All inquiries must contain the name, address, and affiliation of the inquirer and they must provide enough information for the Task Force members to fully understand the point of concern in the inquiry. Where that point is not clearly defined, the inquiry will be returned for clarification. Inquiries should be typewritten – electronic mail is acceptable.

Each inquiry should be limited to a single point unless the inquiry involves two or more interrelated concerns. And, the inquiry should be concise, yet complete, to enable the Task Force members to quickly and fully understand the point of inquiry. Sketches should be used when appropriate and all paragraphs, figures and tables, which relate to the inquiry, must be provided.

Telephone inquiries to WABO concerning the WABO Standard 27-13 should be limited to questions of a general nature or to matters directly related to administration of the WABO Welder Certification Program. WABO Board of Directors policy requires that all program support personnel respond to a telephone request for a technical inquiry with information that such an inquiry can only be obtained through a written request. Welder program support personnel can not provide consulting services.

SECTION 27-13.12 – CHALLENGES AND APPEALS

An agency contact of a registered agency or certified welder in the WABO Welder Qualifying Agency Registration and Welder Certification Program may challenge or appeal, in writing, upon any ground, the result of an agency survey/audit; individual application review, examination or interview; or, any program-related disciplinary action.

A challenge shall be submitted in writing to and reviewed by the WABO executive director, or designee, pursuant to the procedures adopted to implement this policy. If the challenge is rejected by the executive director, or their designee, the challenger may then appeal in writing to the WABO Certification and Registration Committee.

If the challenge is rejected by the Certification and Registration Committee, the challenger may then appeal in writing to the WABO Executive Board. If the WABO Executive Board denies the appeal, the challenger's final right of appeal shall be to a Hearing Officer appointed by the WABO Executive Board, pursuant to the procedures adopted to implement this policy.

SECTION 27.13.13 – SUSPENSION AND WITHDRAWALS

The registration of a specific agency and/or the certification of its personnel may be suspended or withdrawn, pursuant to the procedures adopted to implement this policy.

Failure to abide by any terms of a suspension may result in registration for the agency and/or certification of its personnel being withdrawn.

A registration or certification need not have been suspended before being withdrawn.

WABO executive director shall advise the agency contact person of his/her right to challenge or appeal a suspension or withdrawal action.

LIST OF FIGURES

LIST OF FIGURES
(Continued)

QUALIFICATIONS TEST POSITIONS - GROOVE

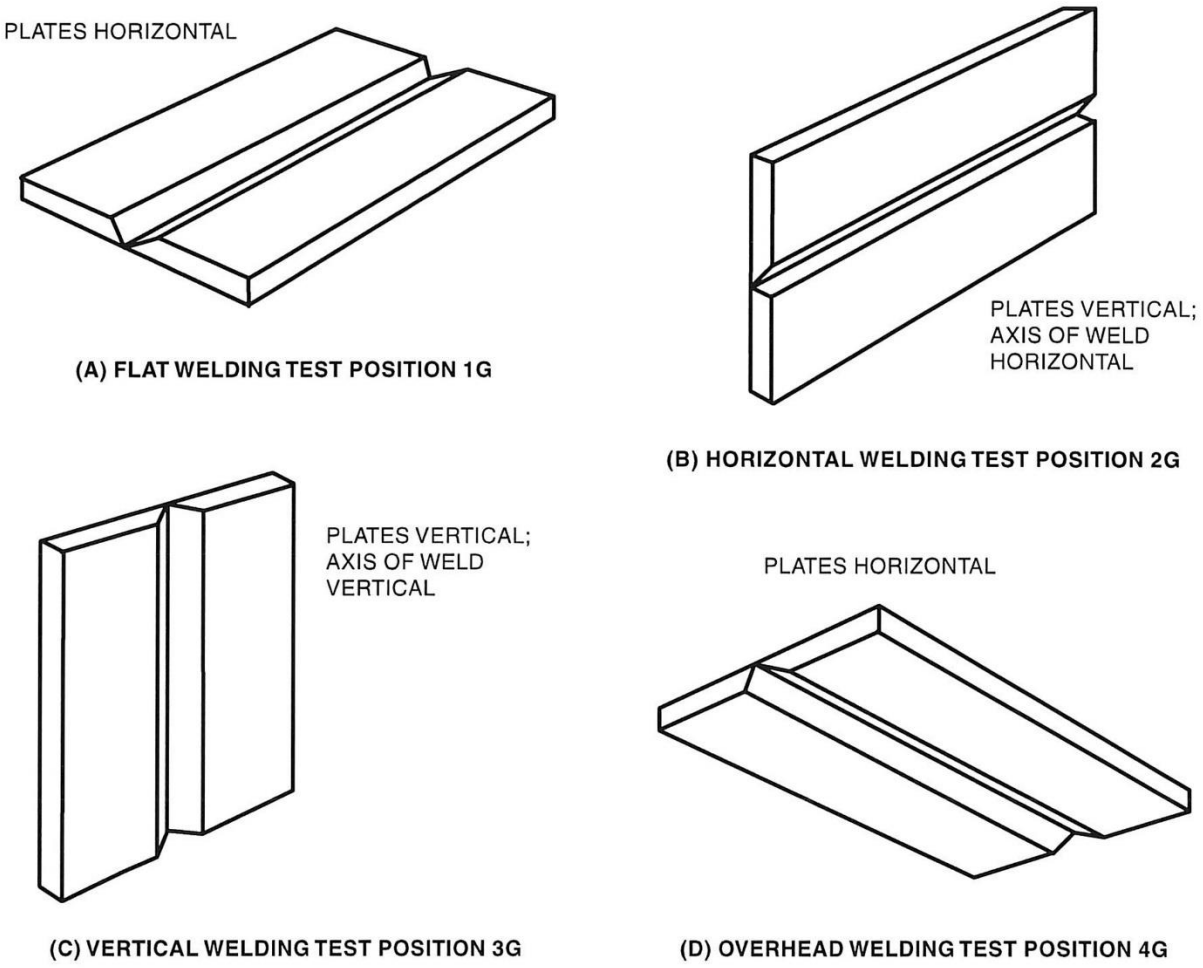
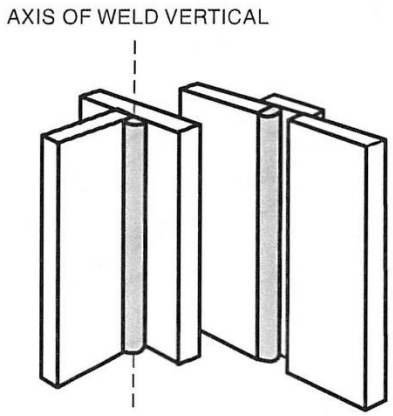


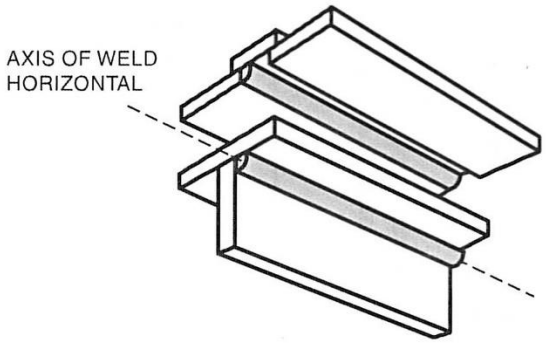
Figure 27-13.01

Source: AWS D1.1/D1.1M:2020, Structural Welding Code- Steel, Figure 6.3 - Positions Test Plates for Groove Welds

QUALIFICATION TEST POSITIONS - FILLET



VERTICAL WELDING TEST POSITION 3F



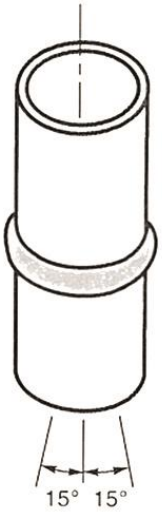
Note: One plate must be horizontal.

OVERHEAD WELDING TEST POSITION 4F

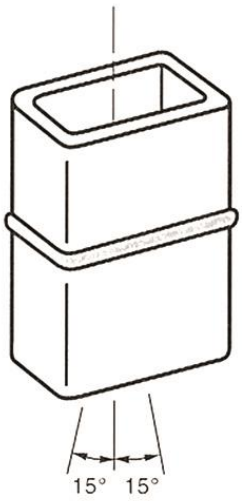
Figure 27-13.02

Source: AWS D1.1/D1.1M:2020, Structrual Welding Code - Steel, portion of Figure 6.4 - Positions Test Plates for Fillet Welds

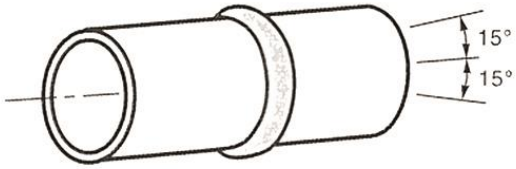
QUALIFICATIONS TEST POSITIONS - TUBULAR

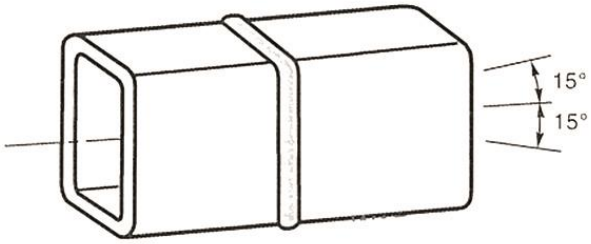


PIPE OR TUBE VERTICAL AND
NOT ROTATED DURING WELDING.
WELD HORIZONTAL (±15°).



Horizontal Welding Test Position 2G





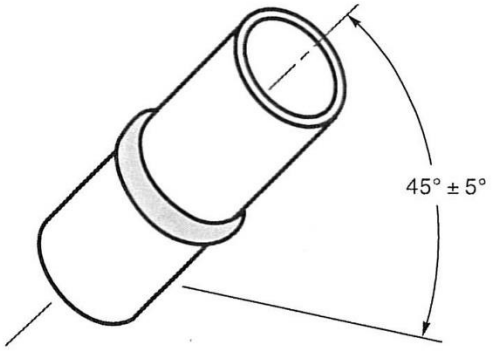
PIPE OR TUBE HORIZONTAL FIXED (±15°) AND NOT ROTATED DURING WELDING
WELD FLAT, VERTICAL, OVERHEAD.

Multiple Welding Test Position 5G

Figure 27-13.03

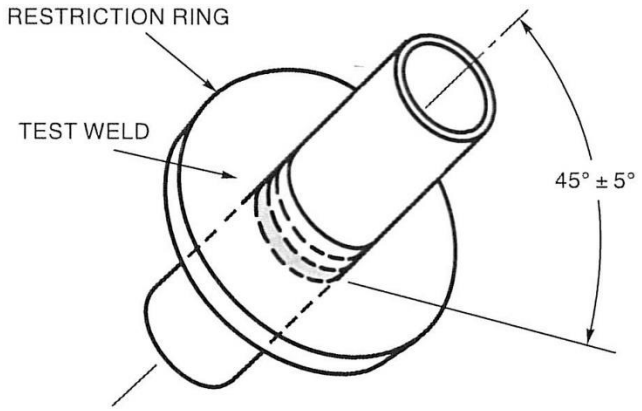
Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 10.12 - Positions of Test Pipe or Tubing for Groove Welds

QUALIFICATIONS TEST POSITIONS - TUBULAR



PIPE INCLINATION FIXED (45° ± 5°) AND NOT ROTATED DURING WELDING.

(D) MULTIPLE WELDING TEST POSITION 6G



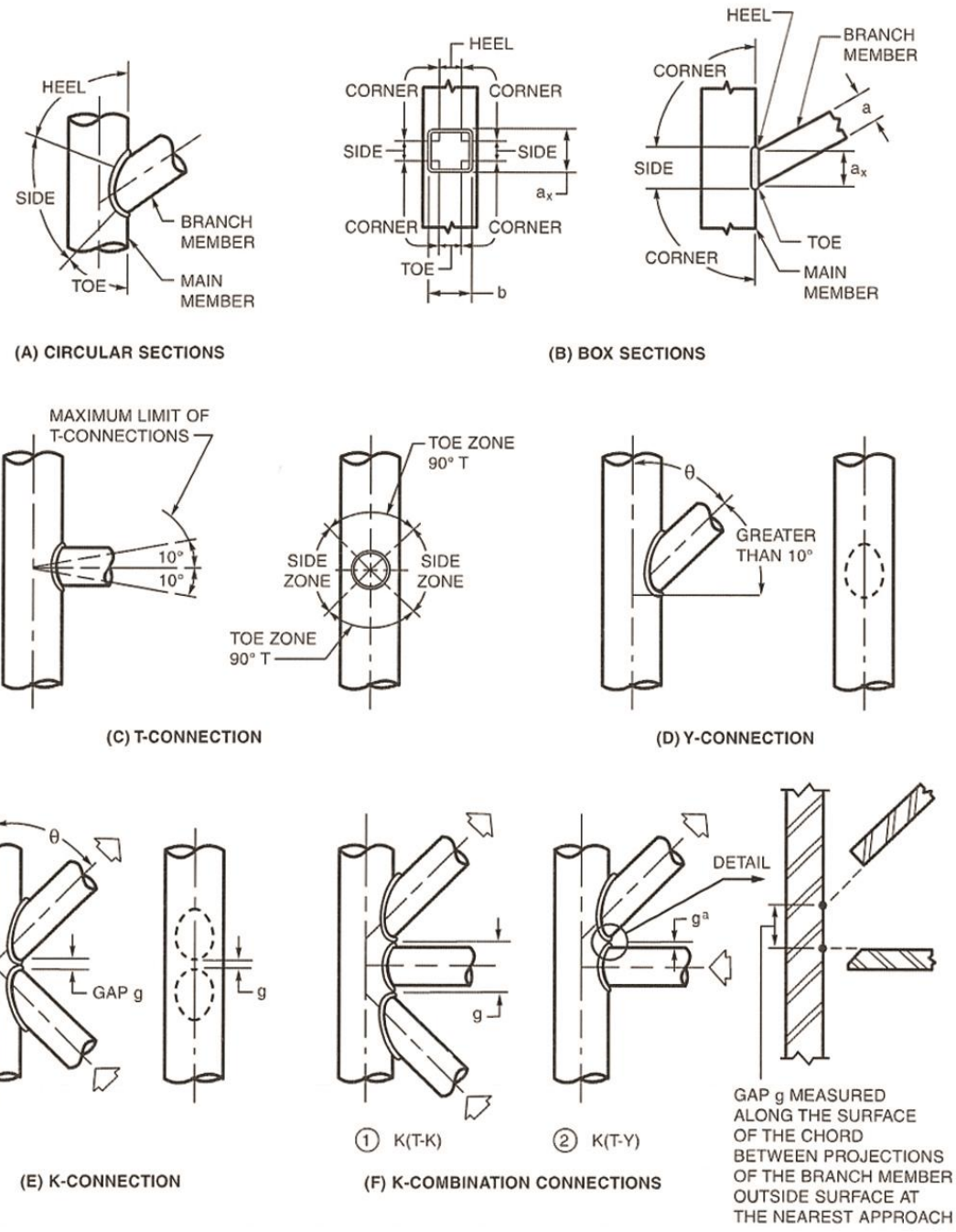
(E) MULTIPLE WELDING TEST POSITION 6GR WITH RESTRICTION RING (T-, Y-, OR K-CONNECTIONS)

Figure 10.12—Positions of Test Pipe or Tubing for Groove Welds (see 10.11.1)

Figure 27-13.04

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 10.12 - Positions of Test Pipe or Tubing for Groove Welds

PARTS OF A TUBULAR CONNECTION

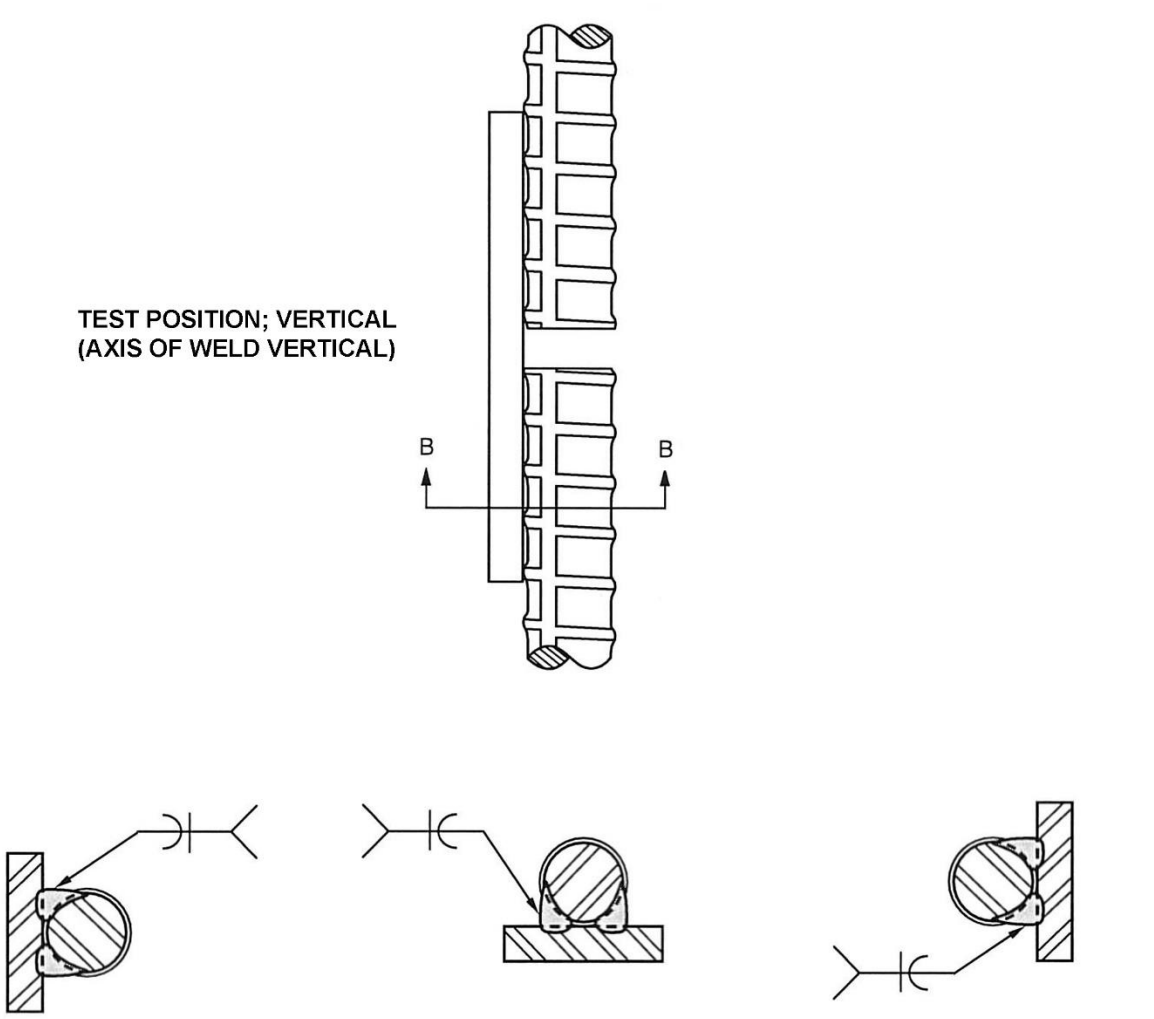


[a] Relevant gap is between braces whose loads are essentially balanced. Type (2) may also be referred to as an N-connection.

Figure 27-13.05

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 10.2 Parts of a Tubular Connection

QUALIFICATION TEST POSITIONS – REINFORCING STEEL



SECTION B-B
MACROETCH SPECIMEN
OF WELDED JOINT

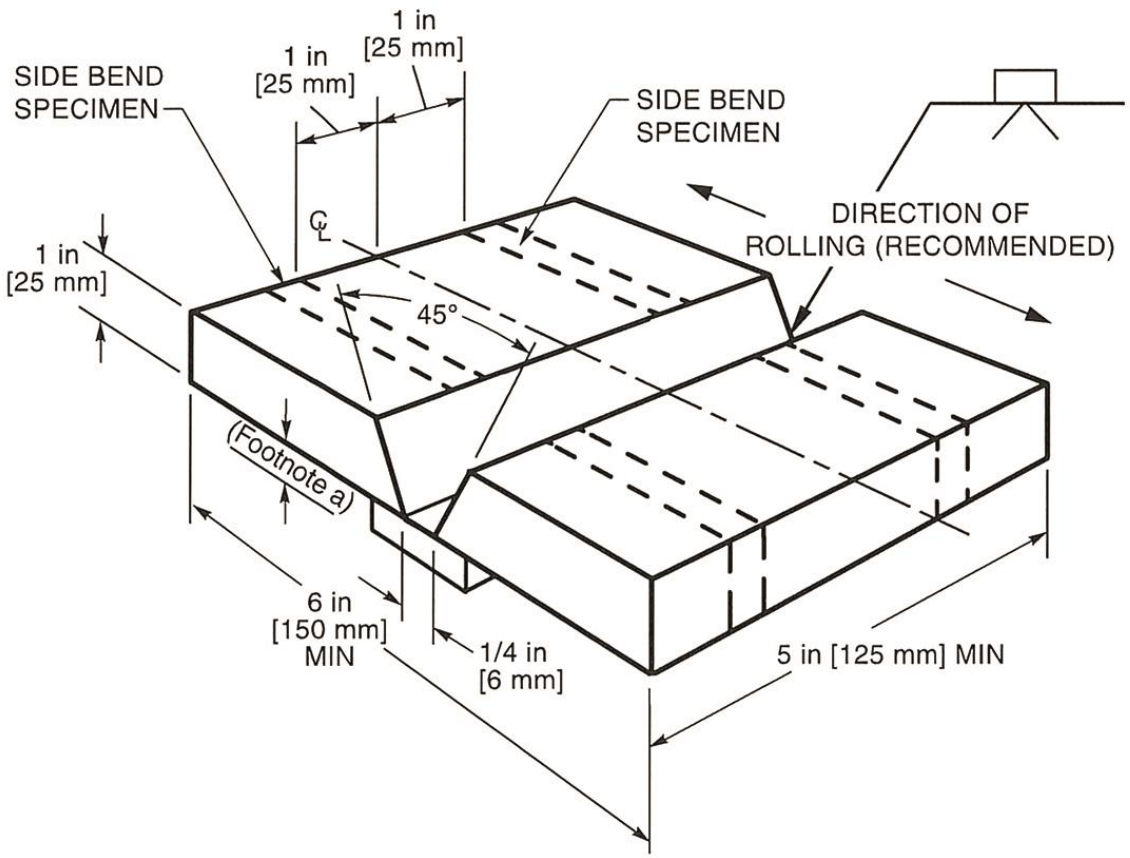
FLARE-BEVEL-GROOVE INDIRECT BUTT-JOINT

B = Separation between ends of bars. Maximum: B = 3/4 in [19 mm].

Figure 27-13.08

Source: AWS D1.4/D1.4M: 2018, Structural Welding Code - Steel Reinforcing Bars, portion of Figure 8.6 - Full Tension Test and Macroetch Test Specimens for Welder Qualification Tests

TEST PLATE FOR WELDER QUALIFICATION
UNLIMITED THICKNESS



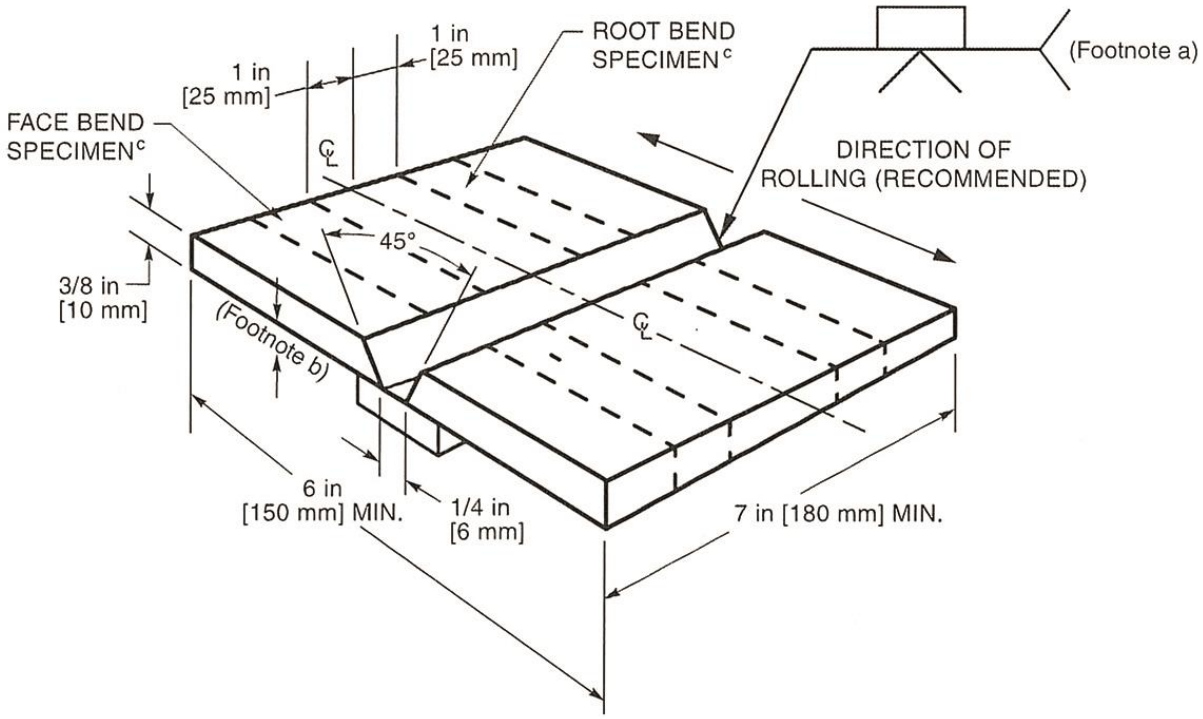
[a] The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1 in [25 mm] min.

Note: When RT is used, no tack welds shall be in test area.

Figure 27-13.09.1

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 6.16 - Test Plate for Unlimited Thickness - Welder Qualification and Fillet Weld Consumable Verification Tests.

TEST PLATE FOR WELDER QUALIFICATION
LIMITED THICKNESS (GMAW AND GTAW ONLY)

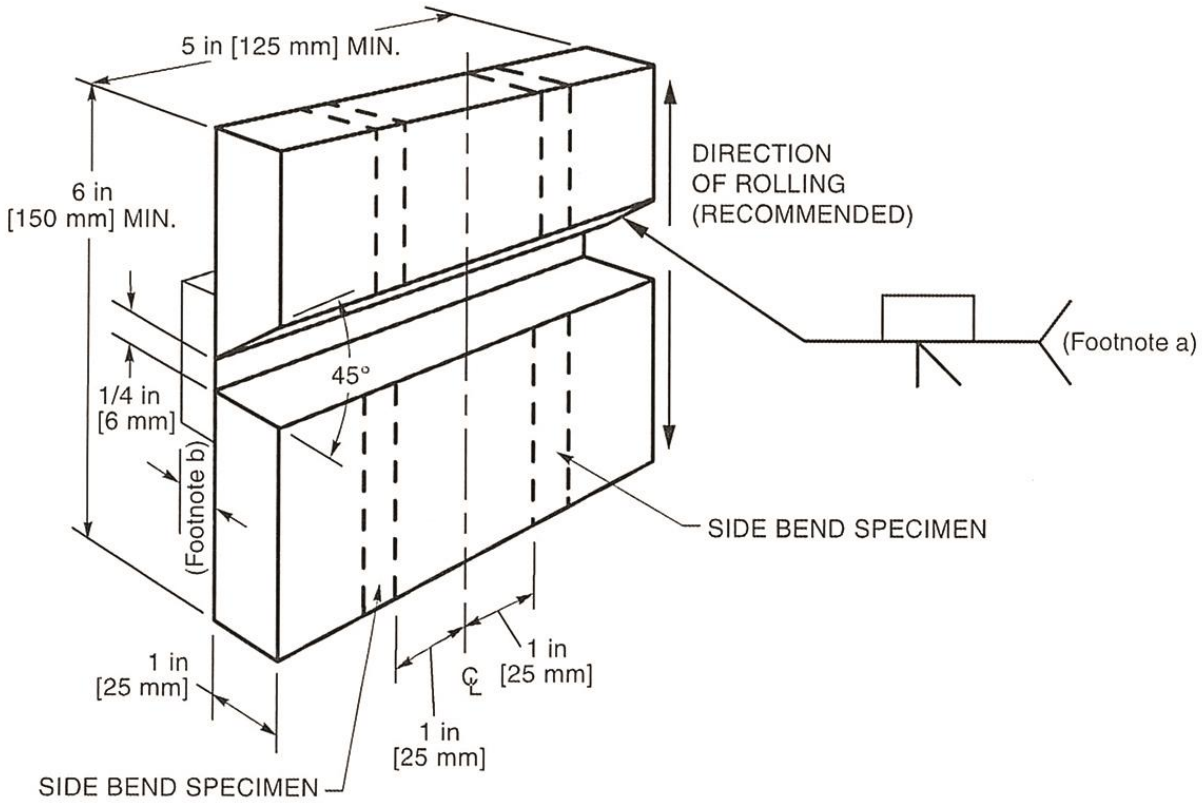


[a] When RT is used, no tack welds shall be in test area.
[b] The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1 in [25 mm] min.
[c] For 3/8 in [10 mm] plate, a side-bend test may be substituted for each of the required face- and root-bend tests.

Figure 27-13.09.2

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 6.20 - Test Plate for Limited Thickness - All Positions- Welder Qualifications

OPTIONAL TEST PLATE FOR WELDER QUALIFICATIONS
HORIZONTAL POSITIONS

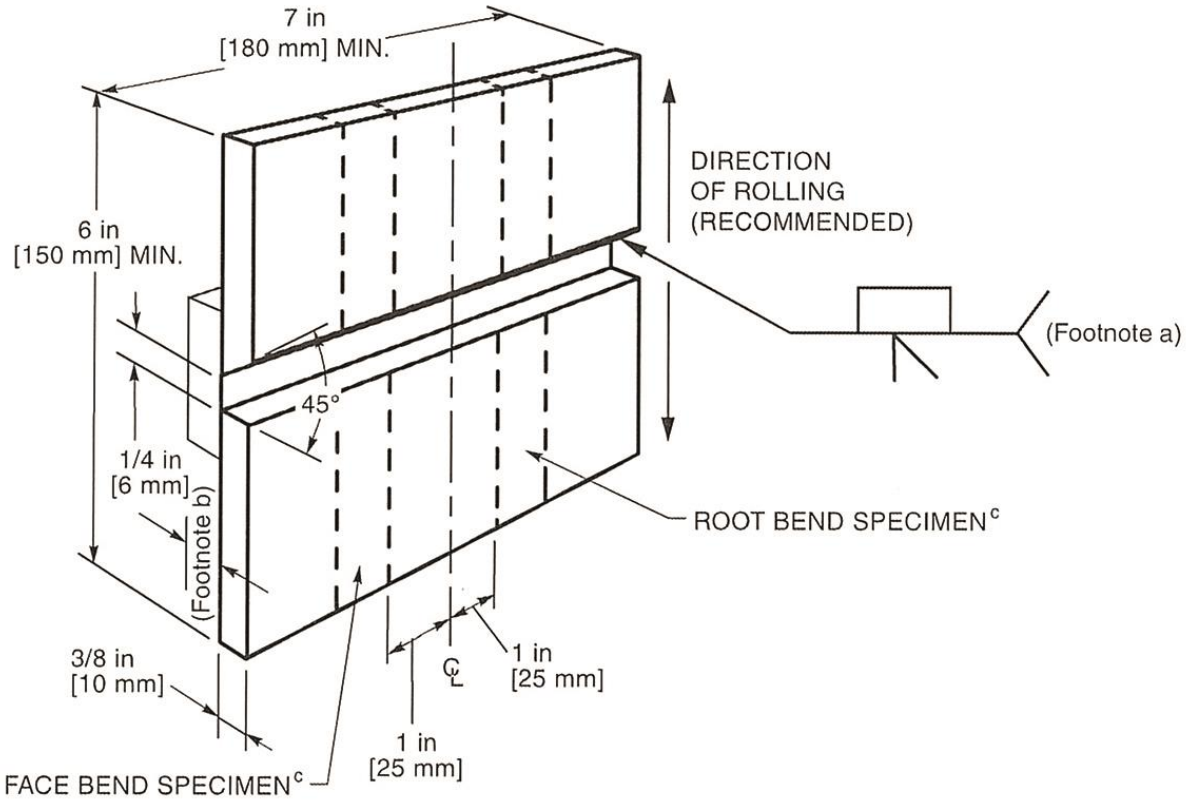


[a] When RT is used, no tack welds shall be in test area.
[b] The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1 in [25 mm] min.

Figure 27-13.09.3

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 6.19 - Optional Test Plate for Unlimited Thickness - Horizontal Position - Welder Qualification

OPTIONAL TEST PLATE FOR WELDER QUALIFICATIONS
HORIZONTAL POSITIONS

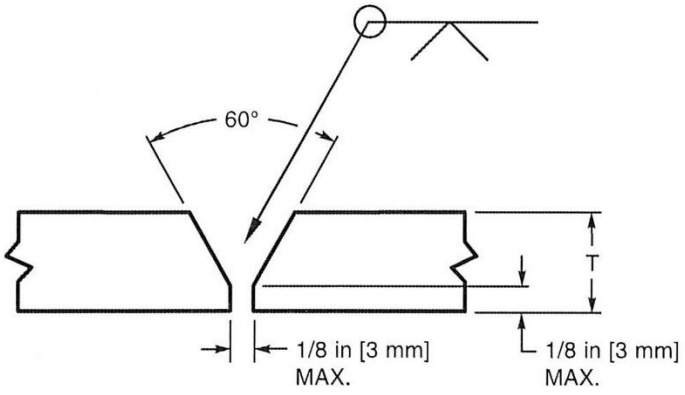


[a] When RT is used, no tack welds shall be in test area.
[b] The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1 in [25 mm] min.
[c] For 3/8 in [10 mm] plate, a side-bend test may be substituted for each of the required face- and root-bend tests.

Figure 27-13.09.4

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 6.21 - Optional Test Plate for Limited Thickness - Horizontal Position - Welder Qualification

TUBULAR BUTT JOINT
Welder Qualification - Without Backing



Note: T = qualification pipe or box tube wall thickness

TUBULAR BUTT JOINT
Welder Qualification - With Backing

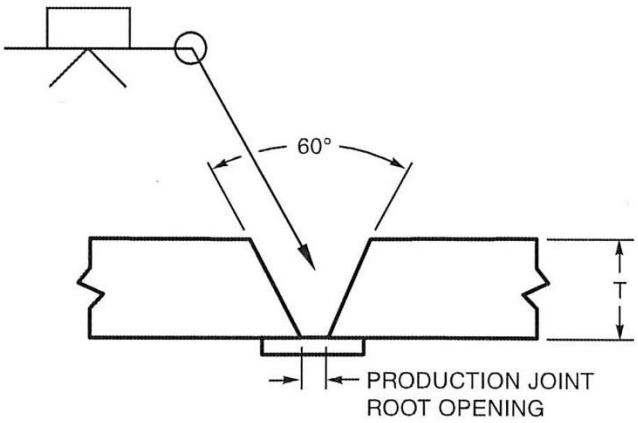


Figure 27-13.09.5

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 10.17 - Tubular Butt Joint - Welder Qualification with and without Backing.

TEST JOINT TYK TUBULAR CONNECTIONS

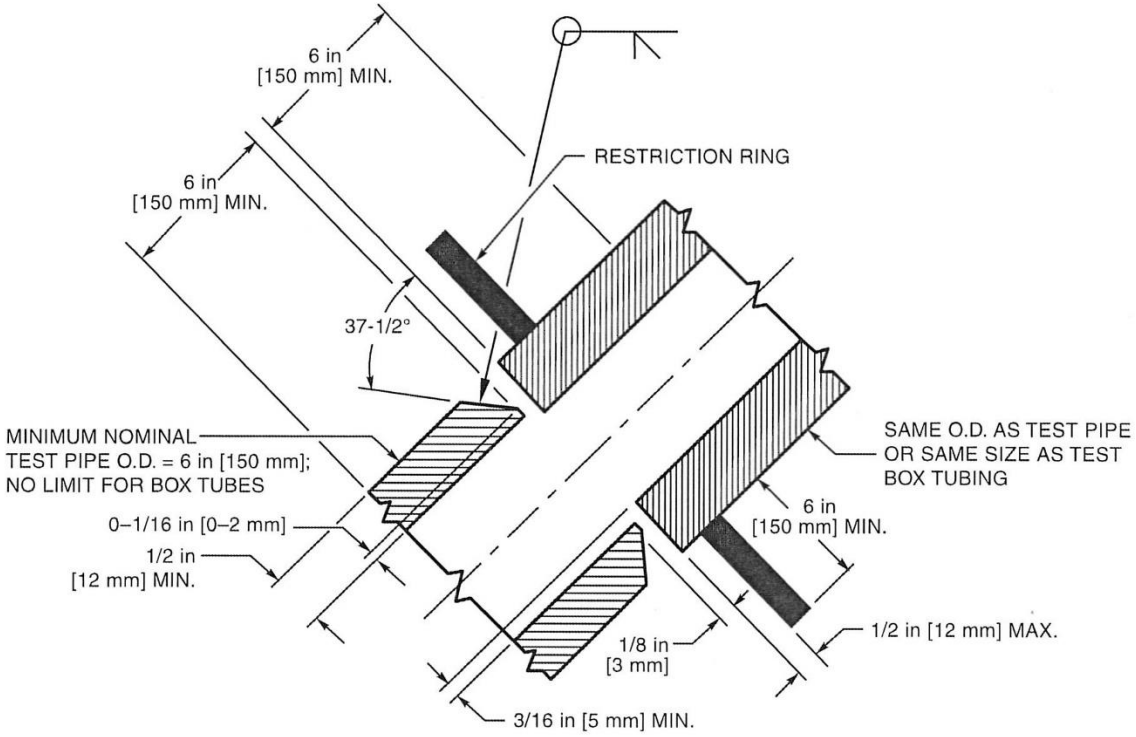


Figure 27-13.09.6

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 10.2 - Test Joint for T-, Y-, and K-Connections without Backing on Pipe or Box Tubing (> 6 in [150 mm] O.D.) - Welder and WPS Qualification

QUALIFICATION TEST CONFIGURATION – SHEET STEEL FILLET WELD TEST ASSEMBLY

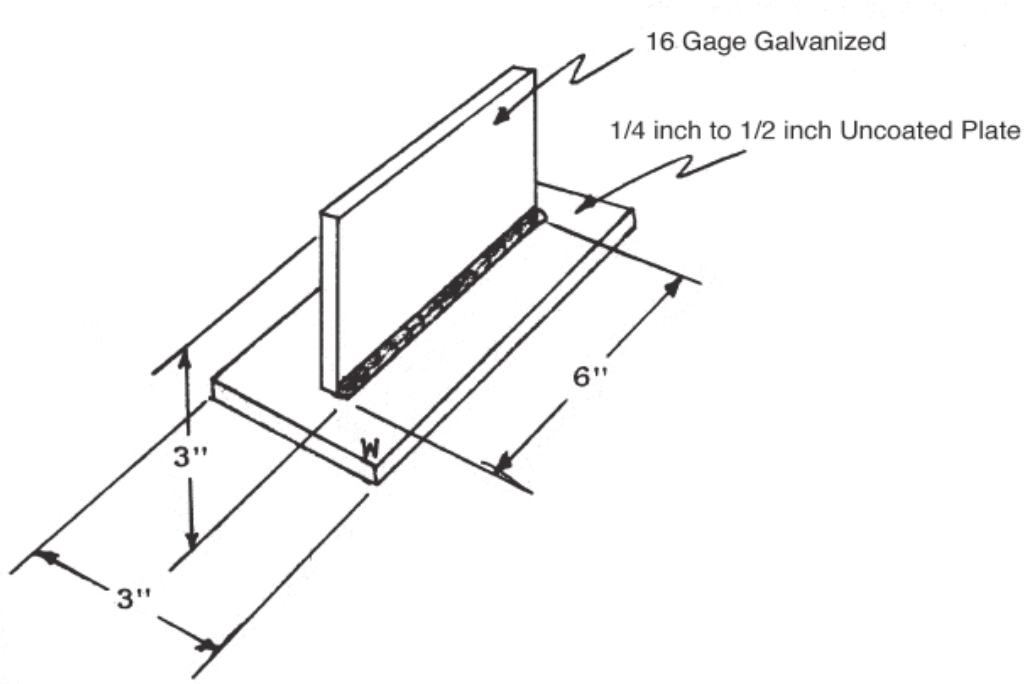
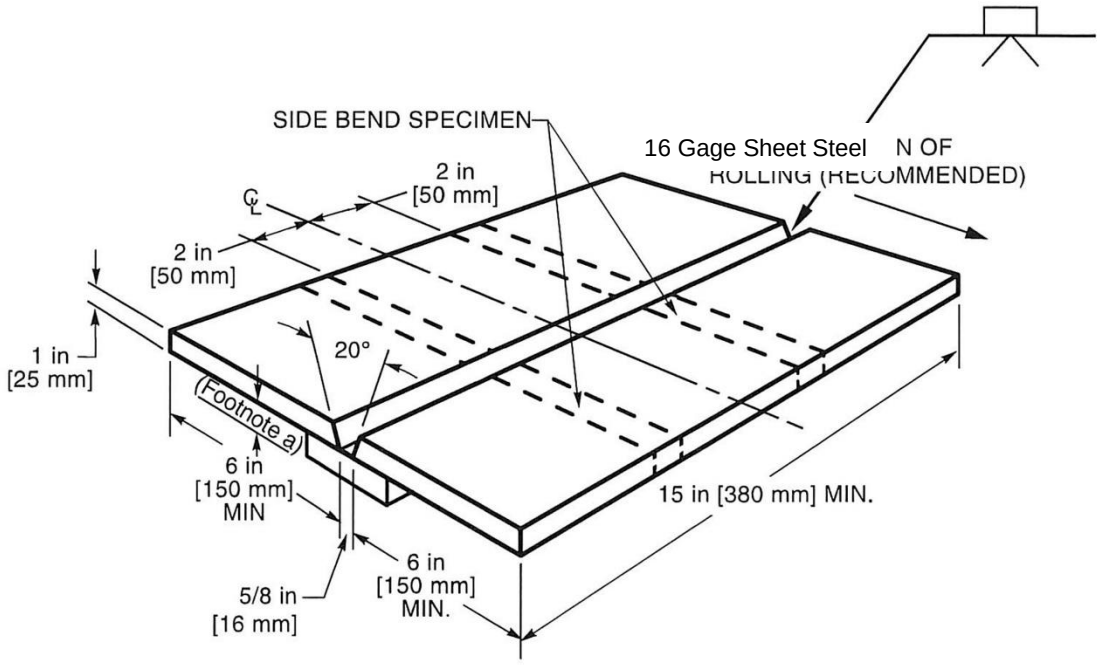


FIGURE 27-13.09.7

QUALIFICATION TEST CONFIGURATION - WELDING OPERATOR - UNLIMITED THICKNESS



[a] The backing thickness shall be 3/8 in [10 mm] min. to 1/2 in [12 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1-1/2 in [40 mm] min.

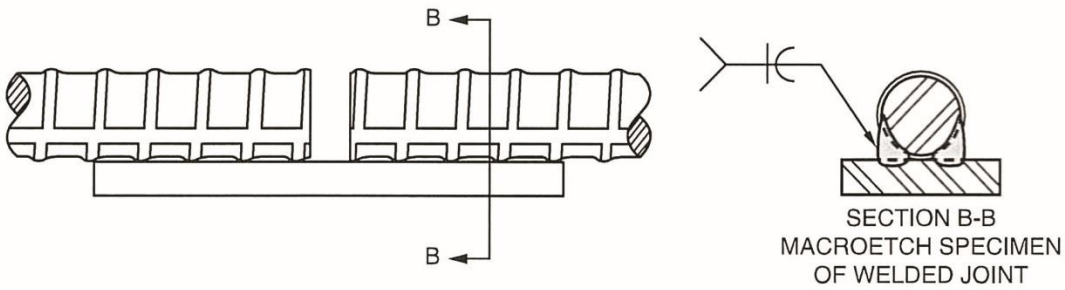
Notes:

1. When RT is used, no tack welds shall be in test area.
2. The joint configuration of a qualified WPS may be used in lieu of the groove configuration shown here.

Figure 27-13.09.8

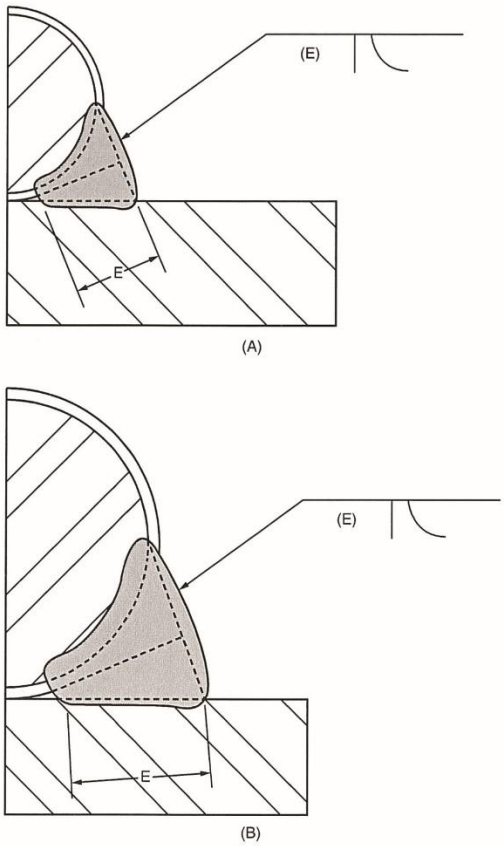
Source: AWS D1.1/D1.1 M: 2020, Structural Welding Code - Steel, Figure 6.17 - Test Plate for Unlimted Thickness - Welder Operator Qualification and Fillet Weld Consumable Verification Tests

QUALIFICATION TEST CONFIGURATIONS - REINFORCING STEEL TEST ASSEMBLY



FLARE-BEVEL-GROOVE INDIRECT BUTT-JOINT

B = Separation between ends of bars. Maximum: B = 3/4 in [19 mm].



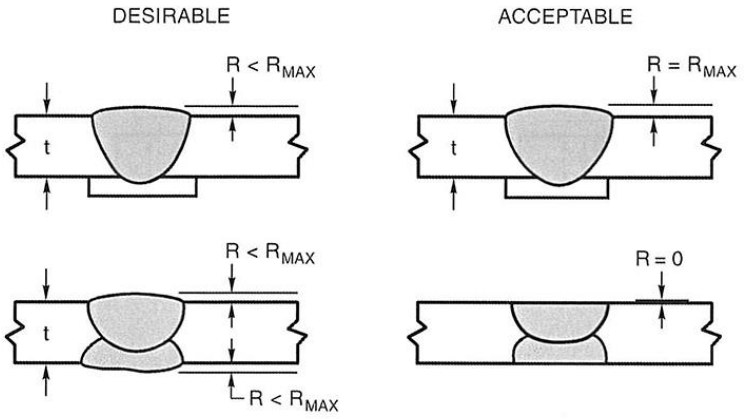
Note: Throat shall be measured as the shortest distance from the theoretical face to the point of fusion at the root as shown in dimension (E).

FLARE-BEVEL GROOVE WELD EFFECTIVE THROAT

Figure 27-13.09.9

Source: AWS D1.4/D1.4M: 2018, Structural Welding Code - Steel Reinforcing Bars, portion of Figure 8.6 - Full Tension Test and Macroetch Test Specimens for Welder Qualification Tests and Figure 8.8 - Flare-Bevel Groove Weld Effective Throat

ACCEPTABLE (DESIRABLE) GROOVE WELD PROFILE - PLATE



WELD PROFILES FOR BUT JOINTS

Figure 27-13.10.1

UNACCEPTABLE GROOVE WELD PROFILE - PLATE

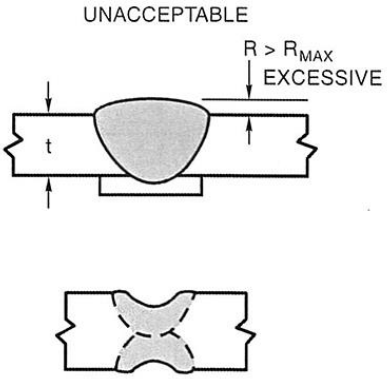
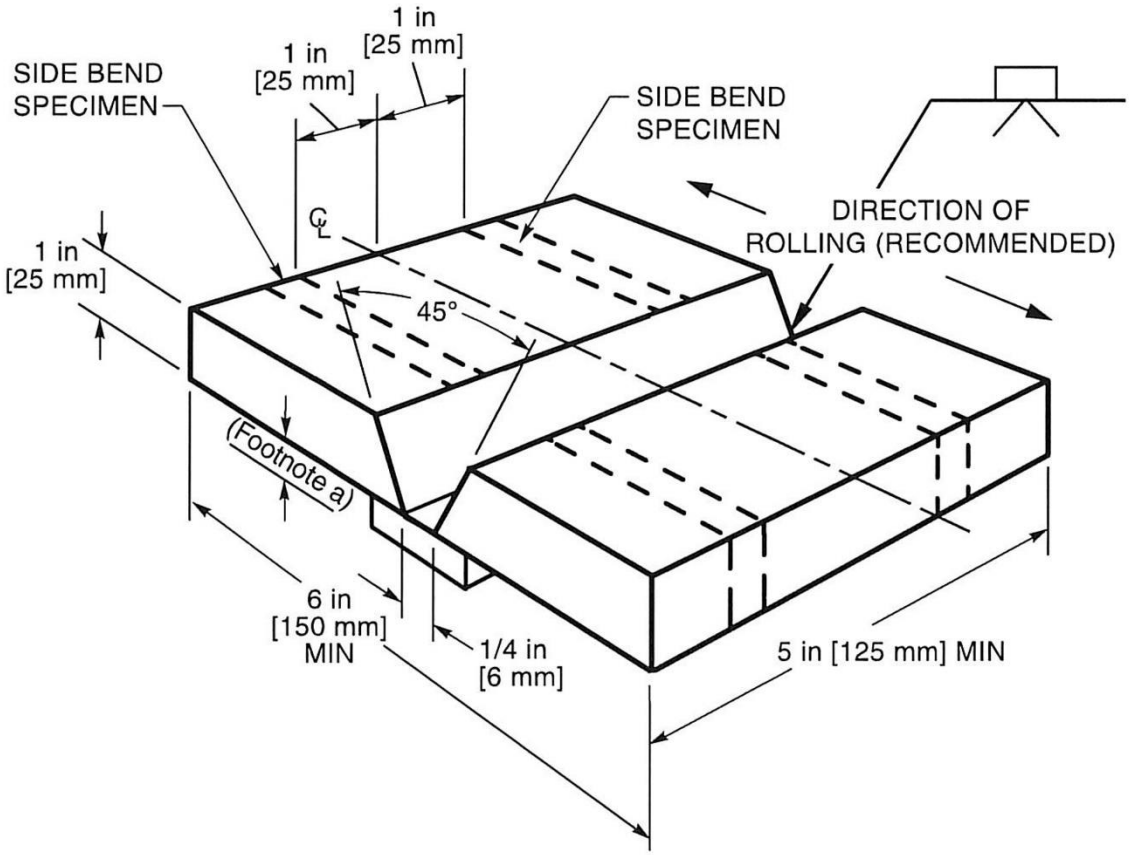


Figure 27-13.10.2

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 7.4 - Requirements for Weld Profiles

GROOVE TEST PLATE – UNLIMITED THICKNESS



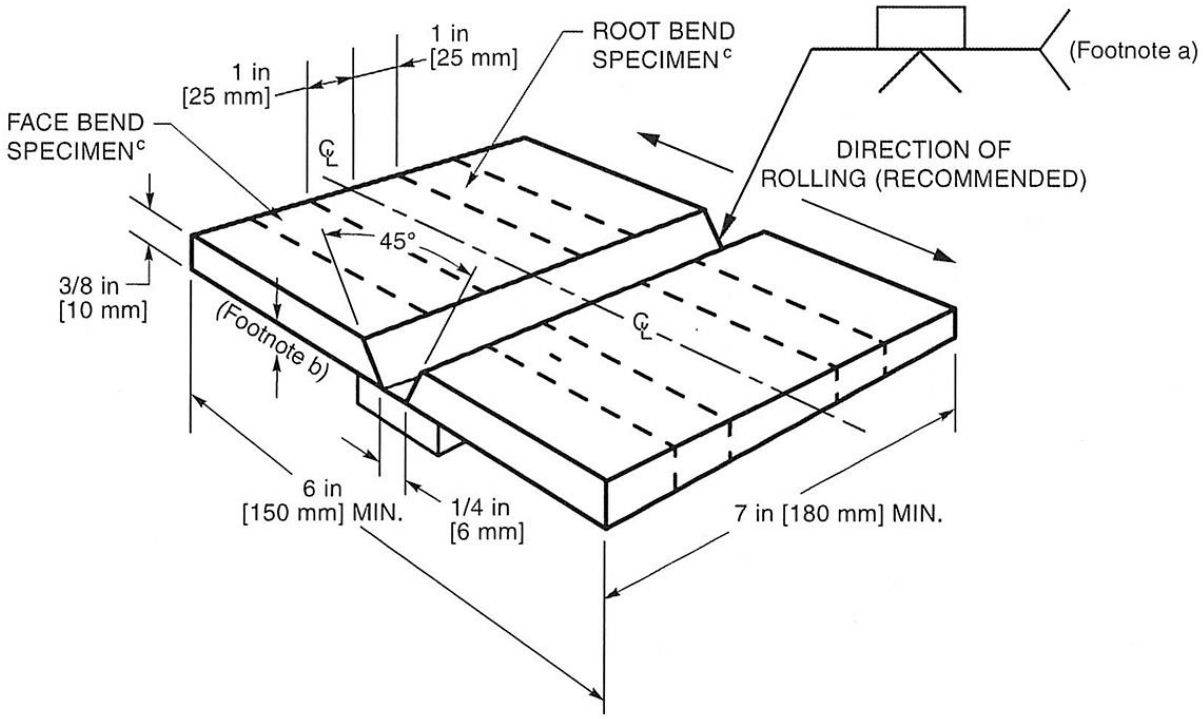
[a] The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1 in [25 mm] min.

Note: When RT is used, no tack welds shall be in test area.

Figure 27-13.11.1

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 6.16 - Test Plate for Unlimited Thickness - Welder Qualification and Fillet Weld Consumable Verification Tests.

GROOVE TEST PLATE - LIMITED THICKNESS
(FOR GMAW AND GTAW ONLY)

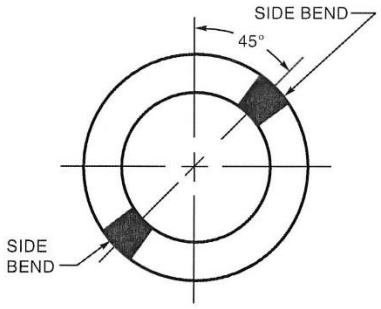


[a] When RT is used, no tack welds shall be in test area.
[b] The backing thickness shall be 1/4 in [6 mm] min. to 3/8 in [10 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1 in [25 mm] min.
[c] For 3/8 in [10 mm] plate, a side-bend test may be substituted for each of the required face- and root-bend tests.

Figure 27-13.11.2

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Figure 6.20 - Test Plate for Limited Thickness - All Positions- Welder Qualifications

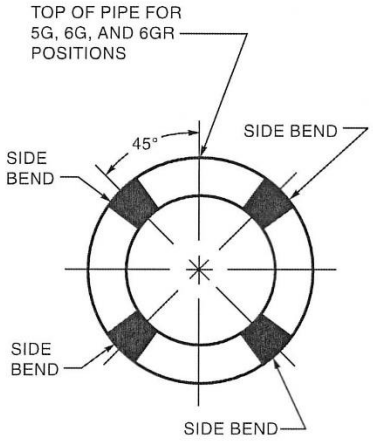
TUBULAR TEST
2G POSITION



PIPE WALL OVER 3/8 in [10 mm]

Figure 27-13.11.3

TUBULAR TEST
5G, 6G & 6GR POSITION

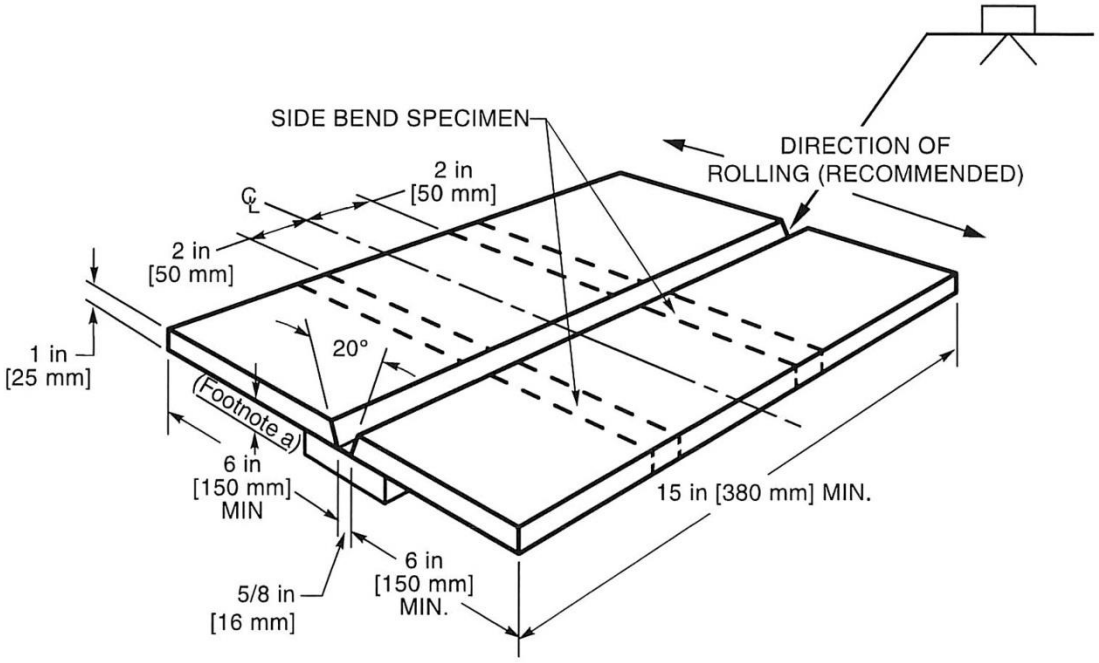


PIPE WALL OVER 3/8 in [10 mm]

Figure 27-13.11.4 & 27-13.11.5

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 10.23 - Location of Test Specimens on Welded Test Pipe and Box Tubing - Welder Qualifications.

WELDING OPERATOR TEST PLATE
UNLIMITED THICKNESS



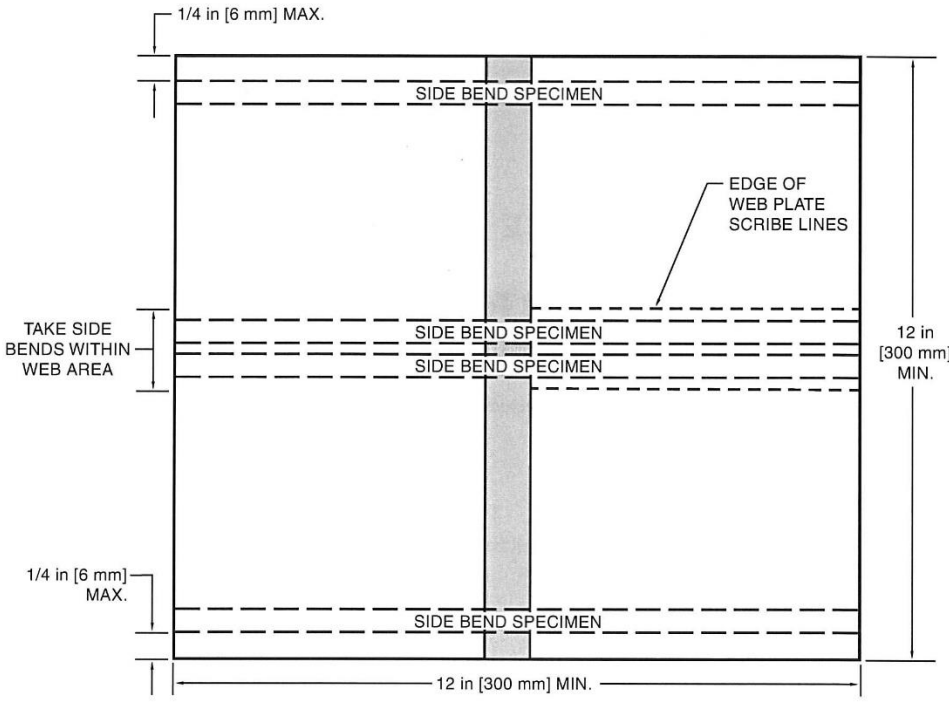
[a] The backing thickness shall be 3/8 in [10 mm] min. to 1/2 in [12 mm] max.; backing width shall be 3 in [75 mm] min. when not removed for RT, otherwise 1-1/2 in [40 mm] min.

Notes:
1. When RT is used, no tack welds shall be in test area.
2. The joint configuration of a qualified WPS may be used in lieu of the groove configuration shown here.

Figure 27-13.11.6

Source: AWS D1.1/D1.1 M: 2020, Structural Welding Code - Steel, Figure 6.17 - Test Plate for Unlimited Thickness - Welder Operator Qualification and Fillet Weld Consumable Verification Tests

LOCATION OF SIDE BEND SPECIMENS ON TEST PLATES - SUPPLEMENTAL WELDER QUALIFICATION



Notes:

1. Test plates shall be a minimum of 1 in [25 mm] thick.
2. The web plate thickness area shall be 1 in [25 mm] thick. The web area shall be clearly marked on the plates before removal. Two side bend specimens shall be taken from within the web area; the entire width of each specimen shall be within the web area.
3. Side bends shall be 3/8 in [10 mm] thick.
4. The two bend specimens taken near the ends of the welds shall be bent so that the side of the bend specimen that was nearest to the end of the weld becomes the convex side (sees the greatest tension).

Figure 27-13.11.7

Source: AWS D1.8/D1.8M: 2016, Structural Welding Code - Seismic Supplement, Figure D.4 - Location of Side Bend Specimens on Test Plates

SIDE - BEND

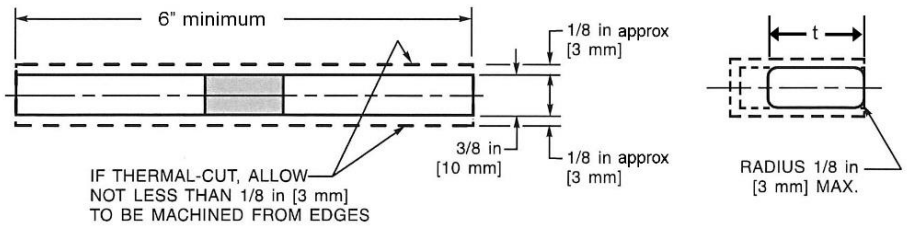
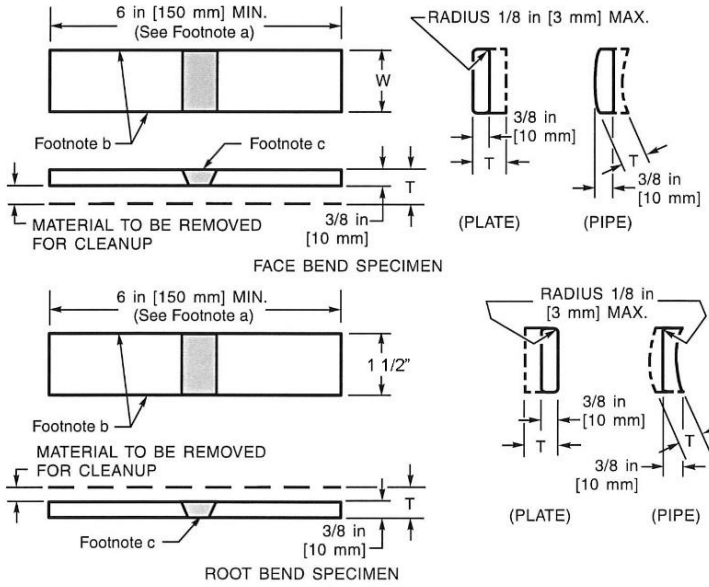


Figure 27-13.11.8

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 6.9 - Side Bend Specimens

FACE AND ROOT BEND



(2) TRANSVERSE BEND SPECIMEN

Dimensions	
Test Weldment	Test Specimen Width, W in [mm]
Plate	1-1/2 l40]
Test pipe or tube ≤ 4 in [100 mm] in diameter	1 [25]
Test pipe or tube > 4 in [100 mm] in diameter	1-1/2 (40]

[a] A longer specimen length may be necessary when using a wraparound type bending fixture or when testing steel with a yield strength of 90 ksi [620 MPa] or more.

[b] These edges may be thermal cut and may or may not be machined.

[c] The weld reinforcement and backing, if any, shall be removed flush with the surface of the specimen. If a recessed backing is used, this surface may be machined to a depth not exceeding the depth of the recess to remove the backing; in such a case, the thickness of the finished specimen shall be that specified above. Cut surfaces shall be smooth and parallel.

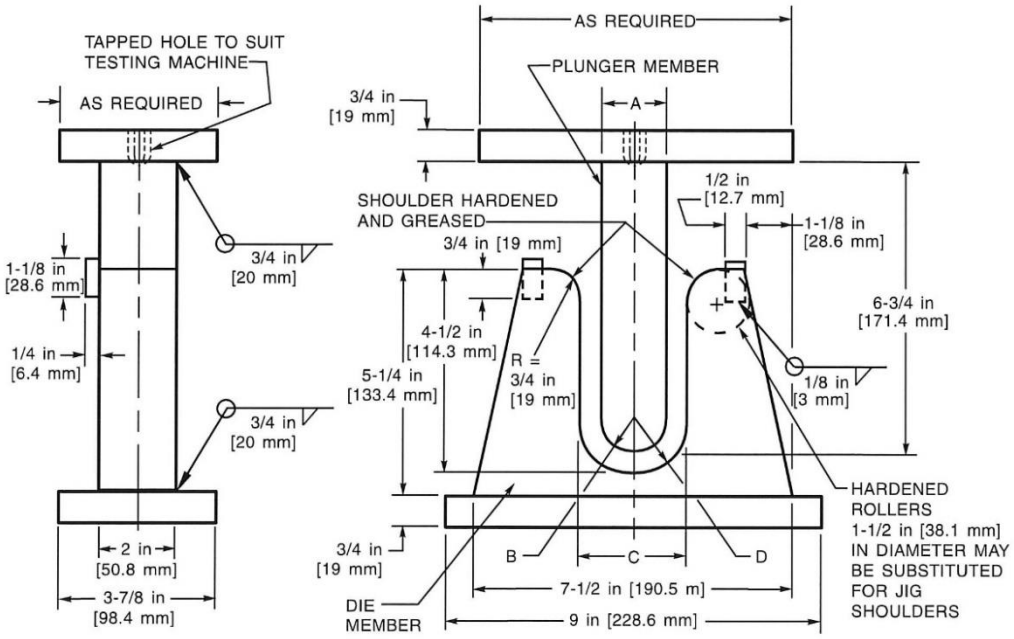
Notes:

1. T = plate or pipe thickness.
2. When the thickness of the test plate is less than 3/8 in [10 mm], the nominal thickness shall be used for face and root bends.

Figure 27-13.11.9

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Figure 6.8 - Face and Root Bend Specimens

GUIDED BEND TEST JIG SPECIFICATIONS

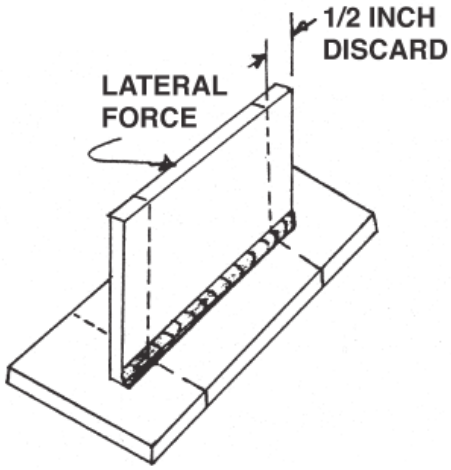


Thickness of Specimens	A	B	C	D	Material
3/8 inch	1-1/2 inch	3/4 inch	2-3/8 inch	1-3/16 inch	All Steels with minimum specified yield strength of 50,000 & under

Figure 27-13.12.1

Source: AWS D1.1/D1.1M: 2020, Structural Welding Code - Steel, Partial Figure 6.11 - Guided Bend Test Jig

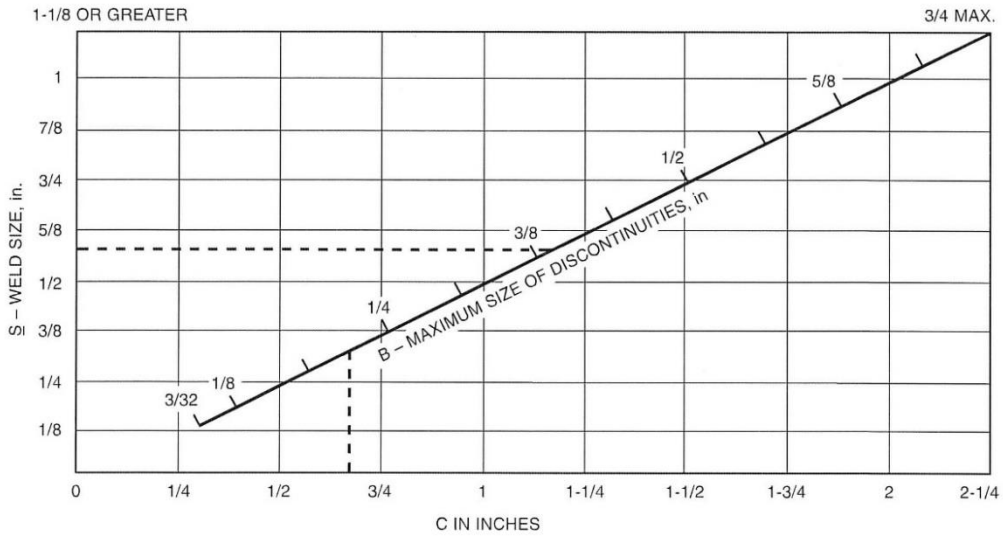
FILLET BREAK SPECIMEN



The fillet weld break specimen shall be cut from the test coupon as shown.

FIGURE 27-13.12.2

RADIOGRAPHIC WELD QUALITY REQUIREMENTS FOR DISCONTINUITIES



Legend for Figure

Dimensions of Discontinuities

B = Maximum allowed dimension of a radiographed discontinuity.
L = Largest dimension of a radiographed discontinuity.
L' = Largest dimension of adjacent discontinuities.
C = Minimum clearance measured along the longitudinal axis of the weld between edges of porosity or fusion-type discontinuities (larger of adjacent discontinuities governs), or to an edge or an end of an intersecting weld.
C1= Minimum allowed distance between the nearest discontinuity to the free edge of a plate or tubular, or the intersection of a longitudinal weld with a girth weld, measured parallel to the longitudinal weld axis.
W = Smallest dimension of either of adjacent discontinuities.

Material Dimensions

S = Weld size
T = Plate or pipe thickness for CJP groove welds

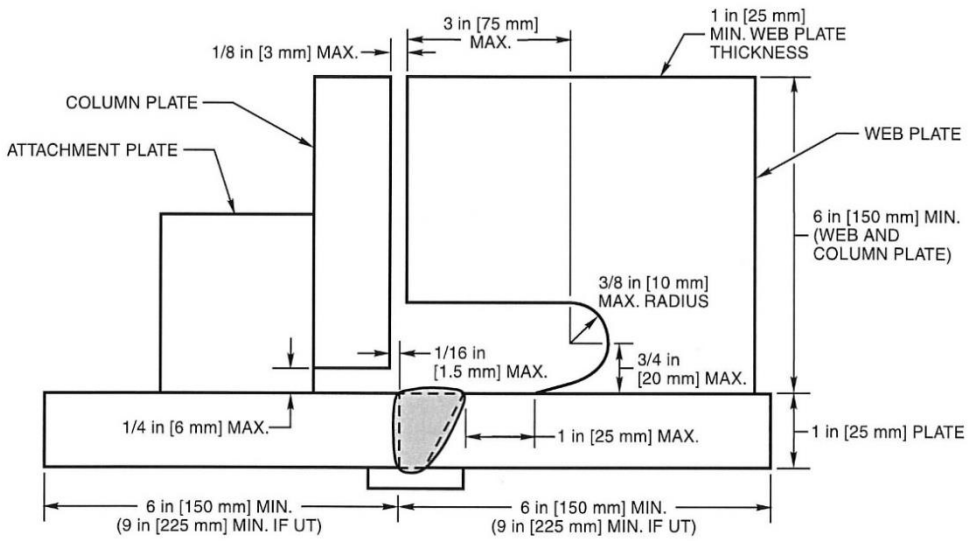
Definitions of Discontinuities

- An elongated discontinuity shall have the largest dimension (L) exceed 3 times the smallest dimension.
- A rounded discontinuity shall have the largest dimension (L) less than or equal to 3 times the smallest dimension.
- A cluster shall be defined as a group of nonaligned, acceptably-sized, individual adjacent discontinuities with spacing less than the minimum allowed (C) for the largest individual adjacent discontinuity (L'), but with the sum of the greatest dimensions (L) of all discontinuities in the cluster equal to or less than the maximum allowable individual discontinuity size (B). Such clusters shall be considered as individual discontinuities of size L for the purpose of assessing minimum spacing.
- Aligned discontinuities shall have the major axes of each discontinuity approximately aligned.

Figure 27-13.13.1

Source: AWS D1 .1/D1 .1 M:2020, Structural Welding Code - Partial Figure .8,.1-Discontinuity Acceptance Criteria for Statically Loaded Non tubular and Statically or Cyclically Loaded Tubular Connections

TEST PLATE CONFIGURATION FOR OPTION A

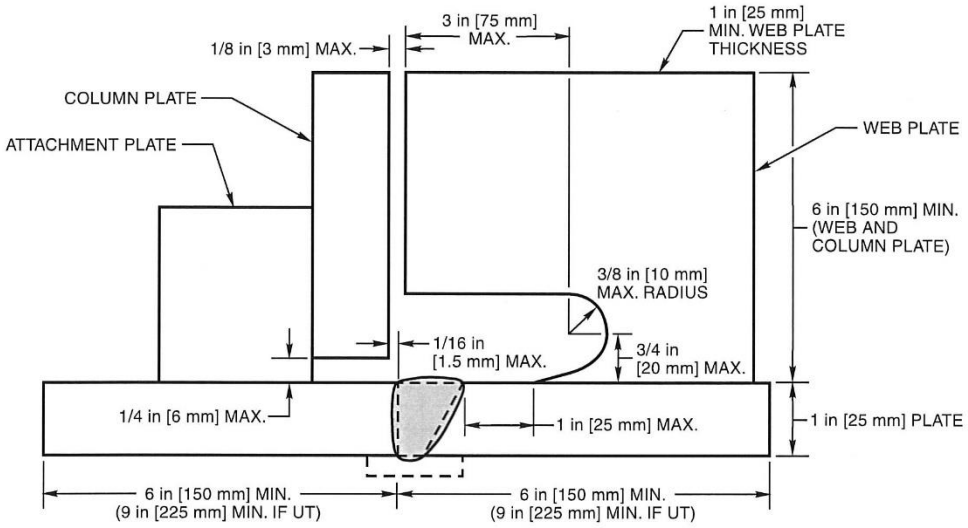


Notes:
1. The weld access hole dimensions are applicable for this test only.
2. Groove dimensions shall be 3/8 in [10 mm] root opening (±1/16 in [1.5 mm]) and 30° bevel (±5°).
3. Backing shall be equal to or greater than 1/4 in [6 mm] but not greater than 3/4 in [20 mm] thick, and shall be a minimum of 1 in [25 mm] wide. The length of the backing shall be 12 in [300 mm], plus run off length, min.
4. The test plates and column plate shall be same length, 12 in [300 mm] min.
5. The attachment plate may be of any size and dimension.
6. The column plate may be any thickness.

Figure 27-13.14.1

Source: AWS D1.8/D1.8M: 2016, Structural Welding Code - Seismic Supplement, Figure D.1 - Test Plate Configuration for Option A

TEST PLATE CONFIGURATION FOR OPTION B

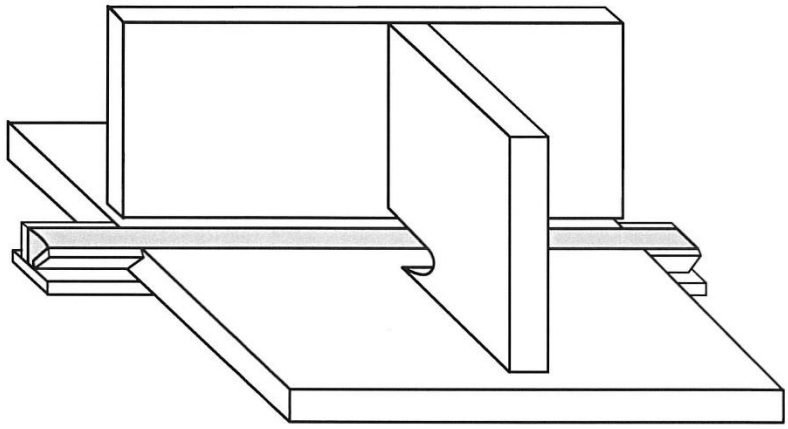


Notes:
1. The weld access hole dimensions are applicable for this test only.
2. Nonsteel backing shall be used or shall be open root.
3. All groove dimensions shall be as specified in the WPS.
4. The test plates and column plate shall be same length, 12 in [300 mm] min.
5. The attachment plate may be of any size and dimension.
6. The column plate may be any thickness.

Figure 27-13.14.2

Source: AWS D1.8/D1.8M: 2016, Structural Welding Code -Seismic Supplement, Partial Figure D.2 - Test Plate Configuration for Option B.

TEST PLATE CONFIGURATION ILLUSTRATION



Notes:
1. The web location shall be marked on the test plates prior to disassembling the test configuration [illegible].
2. The web plate shall be centered on the test plate.

Figure 27-13.14.3

Source: AWS D1.8/D1.8M: 2016, Structural Welding Code - Seismic Supplement, Figure D.3 - Test Plate Configuration Illustration.

LIST OF TABLES

TABLE 27-13-A

SPECIFICATIONS FOR *FIELD* CERTIFICATION
STRUCTURAL WELDER – PLATE

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST PLATES TO WELD IN POSITIONS			THICKNESS OF EACH TEST PLATE	THICKNESS RANGE QUALIFIED	POSITION QUALIFIED
		1G	3G	4G			
SMAW	E7018 E7016	--	1	1	1”	1/8” & OVER	ALL
GMAW	E70C-X ER70S-X	--	1	1	3/8”	1/8” – 3/4”	ALL
FCAW	E71T-X	--	1	1	1”	1/8” & OVER	ALL
GTAW	ER70S-X	--	1	1	3/8”	1/8” – 3/4"	ALL

TABLE 27-13-B

SPECIFICATIONS FOR *SHOP* CERTIFICATION
STRUCTURAL WELDER – PLATE

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST PLATES TO WELD IN POSITIONS			THICKNESS OF EACH TEST PLATE	THICKNESS RANGE QUALIFIED	POSITION QUALIFIED
		1G	2G	3G			
SMAW	E7018 E7016	--	1 OR	-- 1	1”	1/8” & OVER	FH FHV
GMAW	E70C-X ER70S-X	--	1 OR	-- 1	3/8”	1/8” – 3/4”	FH FHV
GMAW	E70C-X E70S-X ER70S-X	--	1	--	1”	1/8” & OVER	FH
FCAW	E71T-X	--	1 OR	-- 1	1”	1/8” & OVER	FH FHV
GTAW	ER70S-X	--	1 OR	-- 1	3/8”	1/8” – 3/4"	FH FHV
SAW	F7XX - EXXX	1	--	--	1”	1/8” & OVER	1G, 1F, 2F

TABLE 27-13-C

SPECIFICATIONS FOR *FIELD* CERTIFICATION
STRUCTURAL WELDER – TUBULAR

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST COUPONS TO WELD IN POSITIONS	TEST PIPE SIZE	PIPE SIZE QUALIFIED	MATERIAL THICKNESS QUALIFIED	PIPE OR PLATE POSITION QUALIFIED
		2G 5G 6G				
SMAW	E7018* E7016*	(1 & 1) OR 1	8” SCHEDULE 80 1/2” OR 6” SCHEDULE 120 9/16”	4” OR LARGER	3/16” & OVER	ALL
GMAW	E70C-X ER70S-X	(1 & 1) OR 1		4” OR LARGER	3/16” & OVER	ALL
FCAW	E71T-X	(1 & 1) OR 1		4” OR LARGER	3/16” & OVER	ALL
GTAW	ER70S-X	(1 & 1) OR 1		4” OR LARGER	3/16” & OVER	ALL

*ROOT PASS MAY BE E6010, E6011, OR GTAW

TABLE 27-13-D

SPECIFICATIONS FOR *SHOP* CERTIFICATION
STRUCTURAL WELDER – TUBULAR

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST COUPONS TO WELD IN POSITIONS	TEST PIPE SIZE	PIPE SIZE QUALIFIED	MATERIAL THICKNESS QUALIFIED	PIPE OR PLATE POSITION QUALIFIED
		2G	8” SCHEDULE 80 1/2” OR 6” SCHEDULE 120 9/16”			
SMAW	E7018* E7016*	1		4” OR LARGER	3/16” & OVER	FH
GMAW	E70C-X ER70S-X	1		4” OR LARGER	3/16” & OVER	FH
FCAW	E71T-X	1		4” OR LARGER	3/16” & OVER	FH
GTAW	ER70S-X	1		4” OR LARGER	3/16” & OVER	FH
*ROOT PASS MAY BE E6010, E6011, OR GTAW						

TABLE 27-13-E

SPECIFICATIONS FOR *FIELD & SHOP* CERTIFICATION
T-, K-, AND Y-CONNECTIONS – TUBULAR

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST COUPONS TO WELD IN POSITIONS	TEST PIPE SIZE	PIPE SIZE QUALIFIED	MATERIAL THICKNESS QUALIFIED	PIPE OR PLATE POSITION QUALIFIED
		6GR	AT LEAST 1/2" THICK			
SMAW	E7018* E7016*	1		T, Y, AND K CONNECTIONS	3/16” & OVER	ALL
GMAW	E70C-X ER70S-X	1		T, Y, AND K CONNECTIONS	3/16” & OVER	ALL
FCAW	E71T-X	1		T, Y, AND K CONNECTIONS	3/16” & OVER	ALL
GTAW	ER70S-X	1		T, Y, AND K CONNECTIONS	3/16” & OVER	ALL
*ROOT PASS MAY BE E6010, E6011, OR GTAW						

TABLE 27-13-F

SPECIFICATIONS FOR *FIELD* CERTIFICATION
SHEET STEEL FILLET WELDER

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST PLATES TO WELD IN POSITIONS		THICKNESS OF EACH TEST PLATE	THICKNESS RANGE QUALIFIED	POSITION QUALIFIED
		3F	4F			
SMAW	E6011 E6010	1	1	16 GA. Galvanized to ¼" – ½" uncoated plate, tee joint	1/16" – 1/8"	ALL
GMAW	E70C-X ER70S-X	1	1		1/16" – 1/8"	ALL
FCAW	E71T-X	1	1		1/16" – 1/8"	ALL
GTAW	ER70S-X	1	1	16 GA. uncoated sheet to ¼" – ½" plate tee joint	1/16" – 1/8"	ALL

TABLE 27-13-G

SPECIFICATIONS FOR *SHOP* CERTIFICATION
SHEET STEEL FILLET WELDER

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST PLATES TO WELD IN POSITIONS	THICKNESS OF EACH TEST PLATE	THICKNESS RANGE QUALIFIED	POSITION QUALIFIED
		3F			
SMAW	E6010 E6011	1	16 GA. Galvanized to ¼" – ½" uncoated plate, tee joint	1/16" – 1/8"	FHV
GMAW	ER70S-X E70C-X	1		1/16" – 1/8"	FHV
FCAW	E71T-X	1		1/16" – 1/8"	FHV
GTAW	ER70S-X	1	16 GA. uncoated sheet to ¼"– ½" plate tee joint	1/16" – 1/8"	FHV

TABLE 27-13-H

SPECIFICATIONS FOR *FIELD* CERTIFICATION
REINFORCING STEEL WELDER

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST PLATES TO WELD IN POSITIONS		BAR SIZE TESTED	BAR SIZE QUALIFIED	POSITION QUALIFIED
		3G	4G			
SMAW	EXX18 EXX16	2	2	NO. 4	NO. 4 & ABOVE	ALL
GMAW	EXXS-X EXXC-X ERXXS-X	2	2	NO. 4	NO. 4 & ABOVE	ALL
FCAW	EXXT-X	2	2	NO 4	NO. 4 & ABOVE	ALL

NOTE: Welder may rotate test piece 180° allowing both sides to be welded in the overhead position. The Welder Examiner may choose to lower the test plate.

TABLE 27-13-I

SPECIFICATIONS FOR *SHOP* CERTIFICATION
REINFORCING STEEL WELDER

	USE ELECTRODE WITH AWS DESIGNATION	QUANTITY OF TEST PLATES TO WELD IN POSITIONS		BAR SIZE TESTED	BAR SIZE QUALIFIED	POSITION QUALIFIED
		1G	2G			
SMAW	EXX18 EXX16	2 OR	-- 2	NO. 4	NO. 4 & ABOVE	F FH
GMAW	EXXC-X ERXXS-X	2 OR	-- 2	NO. 4	NO. 4 & ABOVE	F FH
FCAW	EXXT-X	2 OR	-- 2	NO. 4	NO. 4 & ABOVE	F FH

NOTE: Welder may rotate test piece 180° allowing both sides to be welded in the flat position. The Welder Examiner may choose to lower the test plate.

TABLE 27-13-J

LIMITATION OF CERTIFICATIONS

CATEGORY OF WELDER CERTIFICATE AND TEST REQUIRED					The Welder/Welding Operator is qualified for the following:
Reinforcing Steel Welder	Structural Welder		Sheet Steel Welder	Welding Operator	
Indirect Butt Joint	Groove Plate Test	Pipe Butt & T-K-Y Connection Test	Fillet Weld Test	Groove Plate Test	
	X	X		X	1. All steels listed in Table 27-13-J with yield strengths of 60 ksi or less, and other carbon steels of similar chemistry. Certification welding steels with yield strengths over 60 ksi requires a separate qualification test on that material (e.g., A514 or A572, Gr. 65; or A572, Gr. 70).
			X		2. All those steels listed in this Standard, and other carbon steels of similar chemistry with yield strengths of 80 ksi or less.
X					3. Indirect but joints, lap joints and for fillet welds bar to plate. Direct butt and bar to bar joints are not covered by this Standard.
X	X	X	X	X	4. The welding process and method used in qualification tests only (SMAW, GMAW, FCAW, SAW) certification for all others, including short circuiting (“Short Arc”) GMAW, requires a separate qualification test.
X	X	X			5. All filler metals designated F4 and lower (SMAW process). See Table 27-13-L.
	X	X	X	X	6. All filler metals of the same designation and lower strength than that used in the test.
	X	X		X	7. Grooves and fillets, welding and tacking of plate and pipe or tubing over 24 inches in diameter.
	X	X			8. Grooves and fillets, welding and tacking.
			X		9. Fillet welding and tacking T-, butt- and lap-joints in sheet to sheet and sheet to supporting members. (Observe thickness and material limitation, 1/16 inch – 1/8 inch).
			X		10. Equal to or less than 1/8 inch.
			X		11. All sheet thicknesses between and including 1/16 inch and 1/8 inch.
X					12. All reinforcing steel no. 4 and above.
	X				13. GTAW thickness between and including 1/8 inch and 3/4 inch.
	X				14. GMAW thickness between and including 1/8 inch and 3/4 inch.
	X	X		X	15. Welding with backing material in complete joint penetration welds welded from one side.
	X	X			16. Welding with or without backing material in complete joint penetration welds welded from one side, if the qualification test is done without backing.
			X		17. Welding of sheet to sheet and sheet to supporting members.
ANY SEPARATE TESTS REQUIRED TO QUALIFY A WELDER FOR CONDITIONS NOT COVERED ARE TO BE APPROVED BY WABO AND ADMINISTERED BY A WABO QUALIFIED TESTING AGENCY.					

TABLE 27-13-K
MATCHING FILLER METAL REQUIREMENTS

GROUP	STEEL SPECIFICATION REQUIREMENTS				FILLER METAL REQUIREMENTS		
	Steel Specification		Minimum Yield Point ksi	Tensile Strength Range ksi	Electrode Specification	Minimum Yield Point ksi	Tensile Strength Range ksi
I	ASTM A36		36	58-80	SMAW		
	ASTM A53	Grade B	35	60 min			
	ASTM A106	Grade B	35	60 min	AWS A5.1 or A5.5		
	ASTM A131	Grades A, B D, E	34	58-75	E7016, E7018	60	72 min
	ASTM A139	Grade B	35	60 min			
	ASTM A381	Grade Y35	35	60 min			
	ASTM A500	Grade A	33/39	45 min	SAW		
		Grade B	42/46	58 min			
	ASTM A501		36	58 min	AWS A5.17 or A5.23		
	ASTM A516	Grade 55	30	55-75	F7X-EXXX	60	70-90
		Grade 60	32	60-80			
	ASTM A524	Grade I	35	60-85			
		Grade II	30	55-80	GMAW		
	ASTM A1011	Grade 30	30	49 min			
		Grade 36 Type 1	36	53 min	AWS A5.18		
		Grade 40	40	55 min	ER70S-X, E70S-X	60	72 min
		Grade 45 Type 1	45	60 min	E70C-X, E70S-X		
	ASTM A573	Grade 65	35	65-77			
	ASTM A709	Grade 36 ≤ 3/4 in	36	58-80	FCAW		
	API 5L	Grade B	35	60 min			
	API 5L	Grade X42	42	60 min	AWS A5.20		
	ABS	Grades A, B, D, E[b]	34	58-75	E7XT-X (except -2, -3, -10, -GS)	60	72 min
II	ASTM A131	Grades AH32, DH32, EH32	46	64-85	SMAW		
		Grades AH36, DH36, EH36	51	71-90	AWS A5.1 or A5.5 E7016, E7018	60	72 min
	ASTM A516	Grade 65	35	65-85			
		Grade 70	38	70-90	SAW		
	ASTM A537	Class I ≤ 2 1/2 in	50	70-90			
	ASTM A572	Grade 42	42	60 min	AWS A5.17 or A5.23		
		Grade 50	50	65 min	F7X-EXXX	60	70-90 min
	ASTM A588[b]	≤ 4 in	50	70 min			
	ASTM A595	Grade A	55	65 min			
		Grades B and C	60	70 min			
	ASTM A606[b]	Cold-rolled Grade 45	45	65 min	GMAW		
	ASTM A1008/ A1011	Grade 45 Class 1	45	60 min			
		Grade 50 Class 1	50	65 min	AWS A5.18		
		Grade 55 Class 1	55	70 min	ER70S-X, E70S-X	60	72 min
	ASTM A618	Grades Ib, II wall ≤ 3/4 in	50	70 min	E70C-X, E70S-X		
		Grade III	50	65 min			
	ASTM A633	Grades A	42	63-83			
		Grades C, D ≤ 2 1/2 in	50	70-90	FCAW		
	ASTM A709	Grade 50	50	65 min	AWS A5.20		
		Grade 50W[b]	50	70 min	E7XT-X	60	72 min
	ASTM A710	Grade A, Class 2 > 2 in ≤ 4 in	55	65 min	(Except -2, -3, -10, -GS)		
	API 2H		42	62-82			
	API 5L	Grade X52	52	66			
	ABS	Grades AH32, DH32, EH32	46	64-85			
		Grades AH36, DH36, EH36[b]	51	71-90			

Source: AWS:D1.1/D1.1M: 2020, Structural Welding Code - Steel, partial Table 5.3 - Approved Base Metals for Prequalified WPSs & partial Table 5.4 Filler Metals for Matching Strength for Table 5.3.

TABLE 27-13-L

SHEET STEEL

Steel Specification		Minimum Yield Point ksi	Minimum Tensile Strength ksi	Filler Metal Requirements
A653	Gr 33	33	45	
	Gr 37	37	52	SMAW AWS A5.1 or
	Gr 40	40	55	A5.5
A1011	Gr 30	30	49	E6010
	Gr 33	33	52	E6011
	Gr 36 Type 1	36	53	
	Gr 36 Type 2	36	58-80	
	Gr 40	40	55	
	Gr 45 Type 1	45	60	GMAW AWS A5.18
	Gr 45 Type 2	45-60	60	E70S-X
	Gr 45	45	65	ER70S-X
A606/A1008/A1011	Gr 45	45	60	
	Gr 50	50	65	
A1008	Gr 25	25	42	FCAW AWS A5.20
	Gr 30	30	45	E71T-X
	Gr 33 Type 1 & 2	33	48	
	Gr 40 Type 1 & 2	40	52	

Source: AWS D1.3/D1.3M:2018, Structural Welding Code – Sheet Steel, Partial Table 1.2 - Matching Filler Metal Requirements

TABLE 27-13-M

ELECTRODE CLASSIFICATION GROUPS – SMAW PROCESS

Group Designation	AWS Electrode Classification
F4	EXX15, EXX16, EXX18
F3	EXX10, EXX11
F2	EXX12, EXX13, EXX14
F1	EXX20, EXX24, EXX27, EXX28

*The letters “XX” used in the classification-designation in this table stand for the various strength levels (60, 70, 80, 90, 100 and 120) of electrodes.

Source: AWS D1.1/D1.1M:2020, Structural Welding Code – Steel, Partial Table 6.13 Electrode Classification Groups.

TABLE 27-13-N

NOMINAL DIMENSIONS OF ASTM STANDARD REINFORCING BARS

Bar Size[a,b]		Unit Weight		Diameter		Cross - Sectional Area	
US Customary	SI Units	lb / ft	kg / m	in	mm	in^2	mm^2
3	10	0.376	0.56	0.375	9.5	0.11	71
4	13	0.668	0.994	0.500	12.7	0.20	129
5	16	1.043	1.55	0.625	15.9	0.31	199
6	19	1.502	2.24	0.750	19.1	0.44	284
7	22	2.044	3.042	0.875	22.2	0.60	387
8	25	2.670	3.973	1.000	25.4	0.79	510
9	29	3.400	5.060	1.128	28.7	1.00	645
10	32	4.303	6.404	1.270	32.3	1.27	819
11	36	5.313	7.909	1.410	35.8	1.56	1006
14	43	7.650	11.38	1.693	43.0	2.25	1451
18	57	13.60	20.24	2.257	57.3	4.00	258

[a] The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight per foot as the deformed bar.
[b] The bar size number is based on the number of eighths of an inch in the nominal diameter of the bar.

Source: AWS D1.4/D1.4/D1.4M: 2018, Structural Welding Code – Steel Reinforcing Bars, Anex B (Informative) Nominal Dimensions of ASTM Standard Reinforcing Bars.

TABLE 27-13-O
DESIGNATION OF WELDING AND ALLIED PROCESSES
(Alphabetically by Process)

Welding and allied processes	Letter designation
adhesive bonding	ABD
arc welding	AW
atomic hydrogen welding	AHW
bare metal arc welding	BMAW
carbon arc welding	CAW
electrogas welding*	EGW
flux cored arc welding	FCAW
gas metal arc welding	GMAW
gas tungsten arc welding	GTAW
plasma arc welding	PAW
shielded metal arc welding	SMAW
stud arc welding	SW
submerged arc welding	SAW
arc welding process variations	
gas carbon arc welding	CAW-G
gas metal arc welding - pulsed arc	GMAW-P
gas metal arc welding - short circuiting arc	GMAW-S
gas tungsten arc welding - pulsed arc	GTAW-P
series submerged arc welding	SAW-S
shielded carbon arc welding	CAN-S
twin carbon arc welding	CAW-T
brazing	B
arc brazing	AB
block brazing	BB
diffusion brazing	DFB
dip brazing	DB
flow brazing	FLB
furnace brazing	FB
induction brazing	IB
infrared brazing	IRB
resistance brazing	RB
torch brazing	TB
twin carbon arc brazing	TCAB
other welding processes	
electron beam welding	EBW
electroslag welding	ESW
flow welding	FLOW
induction welding	1W
laser beam welding	LBW
thermit welding	TW
oxyfuel gas welding	OFW
air acetylene welding	AAW
oxyacetylene welding	OAW
oxyhydrogen welding	OHW
pressure gas welding	PGW

*In the 1976 edition of AWS A24, electro gas welding was designated FCAW-EG and GMAW-EG, depending on the manner of application.

Welding and allied processes	Letter designation
resistance welding	RW
flash welding	FW
high frequency resistance welding	HFRW
percussion welding	PEW
projection welding	RPW
resistance seam welding	RSEW
resistance spot welding	RSW
upset welding	UW
soldering	S
dip soldering	DS
furnace soldering	FS
induction soldering	IS
infrared soldering	IRS
iron soldering	INS
resistance soldering	RS
torch soldering	TS
wave soldering	WS
solid state welding	SSW
cold welding	CW
diffusion welding	DFW
explosion welding	EXW
forge welding	FOW
friction welding	FRW
hot pressure welding	HPW
roll welding	ROW
ultrasonic welding	USW
thermal cutting	TC
arc cutting	AC
air carbon arc cutting	AAC
carbon arc cutting	CAC
gas metal arc cutting	GMAC
gas tungsten arc cutting	GTAC
metal arc cutting	MAC
plasma arc cutting	PAC
shielded metal arc cutting	SMAC
electron beam cutting	EBC
laser beam cutting	LBC
oxygen cutting	OC
chemical flux cutting	FOC
metal powder cutting	POC
oxyfuel gas cutting	OFC
oxyacetylene cutting	OFC-A
oxyhydrogen cutting	OFC-H
oxynatural gas cutting	OFC-N
oxypropane cutting	AOC
oxygen arc cutting	AOC
oxygen lance cutting	LOC
thermal spraying	THSP
electric arc spraying	EASP
flame spraying	FLSP
plasma spraying	PSP

TABLE 27-13-P
DESIGNATION OF WELDING AND ALLIED PROCESSES
(Alphabetically by Designation)

Letter designation	Welding and allied processes	Letter designation	Welding and allied processes
AAC	air carbon cutting	IB	induction brazing
AAW	air acetylene welding	INS	iron soldering
ABD	adhesive bonding	IRB	infrared brazing
AB	arc brazing	IRS	infrared soldering
AC	arc cutting	IS	induction soldering
AHW	atomic hydrogen welding	IW	induction welding
AOC	oxygen arc cutting	LBC	laser beam cutting
AU	automatic	LBW	laser beam welding
AN	arc welding	LOC	oxygen lance cutting
B	brazing	MA	manual
BB	block brazing	MAC	metal arc cutting
BMAW	bare metal arc welding	ME	machine
CAC	carbon arc cutting	OAW	oxyacetylene welding
CAW	carbon arc welding	OC	oxygen cutting
CAW-G	gas carbon arc welding	OFC	oxyfuel gas cutting
CAW-S	shielded carbon arc welding	OFC-A	oxyacetylene cutting
CAW-T	twin carbon arc welding	OFC-H	oxyhydrogen cutting
CW	cold welding	OFC-N	oxynatural gas cutting
DB	dip brazing	OFC-P	oxypropane, cutting
DFB	diffusion brazing	OFW	oxyfuel gas welding
DFW	diffusion welding	OHW	oxyhydrogen welding
DS	dip soldering	PAC	plasma arc cutting
EASP	electric arc spraying	PAW	plasma arc welding
EBC	electron beam cutting	PEW	percussion welding
EBW	electron beam welding	PGW	pressure gas welding
EGW	electrogas welding	POC	metal powder cutting
ESW	electroslag welding	PSP	plasma spraying
EXW	explosion welding	RB	resistance brazing
FB	furnace brazing	RPW	projection welding
FCAW	flux cored arc welding	RS	resistance soldering
FLB	flow brazing	RSEW	resistance seam welding
FLOW	flow welding	RSW	resistance spot welding
FLSP	flame spraying	ROW	roll welding
FOC	chemical flux cutting	RW	resistance welding
FOW	forge welding	S	soldering
FRW	friction welding	SA	semiautomatic
FS	furnace soldering	SAW	submerged arc welding
FW	flash welding	SAW-S	series submerged arc cutting
GMAC	gas metal arc cutting	SMAC	shielded metal arc cutting
GMAW	gas metal arc welding	SMAK	shielded metal arc -welding
GMAW-P	gas metal arc welding - pulsed arc	SSW	solid state welding
		SW	stud arc welding
GMAW-S	gas metal arc welding - short circuiting arc	TB	torch brazing
		TC	thermal cutting
GTAC	gas tungsten arc cutting	TCAB	twin carbon arc brazing
GTAW	gas tungsten arc welding	THSP	thermal spraying
GTAW-P	gas tungsten arc welding pulsed arc	is	torch soldering
		TW	thermit welding
HFRW	high frequency resistance welding	UsW	ultrasonic welding
HPW	hot pressure welding	UW	upset welding

TABLE 27-13-Q

TERMS AND DEFINITIONS

ALL-WELD-METAL TEST SPECIMEN – A test specimen with the reduced section composed wholly of weld metal.

ANGLE OF BEVEL – See preferred term *bevel angle.*

ARC GOUGING – An arc cutting procedure used to form a bevel or groove.

AS-WELDED – The condition of weld metal, welded joints and weldments after welding prior to any subsequent thermal, mechanical, or chemical treatments.

AUTOMATIC WELDING – Welding with equipment which performs the welding operation without adjustment of the controls by a welding operator. The equipment may or may not perform the loading and unloading of the work. See *machine welding.*

AXIS OF A WELD – A line through the length of a weld perpendicular to and at the geometric center of its cross section.

BACK GOUGING – The removal of weld metal and base metal from the other side of a partially welded joint to assure complete penetration upon subsequent welding from that side.

BACKING – Material (metal, weld metal, carbon or granular) placed at the root of a weld joint for the purpose of supporting molten weld metal.

BACKING PASS – A pass made to deposit a backing weld.

BACKING RING – Backing in the form of a ring, generally used in the welding of piping.

BACKING STRAP – See preferred term *backing strip.*

BACKING STRIP – Backing in the form of a strip.

BACKING WELD – Backing in the form of a weld.

BACKUP WELD (tubular structures) – The initial closing pass in a complete joint penetration groove weld, made from one side only, which serves as a backing for subsequent welding but is not considered as a part of the theoretical weld.

BACK WELD – A weld deposited at the back of a single-groove weld.

BASE METAL – The metal to be welded, soldered, or cut.

BEVEL ANGLE – The angle formed between the prepared edge of a member and a plane perpendicular to the surface of the member.

BOXING – The continuation of a fillet weld around a comer of a member as an extension of the principal weld.

BUTT JOINT – A joint between two members aligned approximately in the same plane.

BUTT WELD – An erroneous term for a weld in a butt joint. See butt joint.

COMPLETE FUSION – Fusion that has occurred over the entire base material surfaces intended for welding and between all layers and weld beads.

COMPLETE JOINT PENETRATION – Joint penetration in which the weld metal completely fills the groove and is fused to the base metal throughout its total thickness.

COMPLETE PENETRATION – See preferred term *complete joint penetration.*

CONSUMABLE GUIDE ELECTROSLAG WELDING – See *electroslag welding.*

CONTINUOUS WELD – A weld which extends continuously from one end of a joint to the other. Where the joint is essentially circular, it extends completely around the joint.

CORNER JOINT – A joint between two members located approximately at right angles to each other.

C02 WELDING – See preferred term *gas metal arc welding.*

CRATER – In arc welding, a depression at the termination of a weld bead or in the molten weld pool.

DEFECT – A discontinuity or discontinuities which by nature or accumulated effect render a part or product unable to meet minimum applicable acceptance standards or specifications. This term designates reject ability.

DEFECTIVE WELD – A weld containing one or more defects.

DEPTH OF FUSION – The distance that fusion extends into the base metal or previous pass from the surface melted during welding.

DISCONTINUITY – An interruption of the typical structure of a weldment such as a lack of homogeneity in the mechanical or metallurgical or physical characteristics of the material or weldment. A discontinuity is not necessarily a defect.

DOWNHAND – See preferred term *flat position.*

EFFECTIVE LENGTH OF WELD – The length of weld throughout which the correctly proportioned cross section exists. In a curved weld, it shall be measured along the axis of the weld.

ELECTROGAS WELDING (EGW) – An arc welding process which produces coalescence of metals by heating with an arc between a continuous filler metal (consumable) electrode and the work. Molding shoe(s) are used to confine the molten weld metal for vertical position welding. The electrodes may be either flux cored or solid. Shielding may or may not be obtained from an externally supplied gas or mixture.

ELECTROSLAG WELDING (ESW) – A welding process producing coalescence of metals with molten slag which melts the filler metal and the surfaces of the work to be welded. The molten weld pool is shielded by this slag which moves along the FULL cross section of the joint as welding progresses. The process is initiated by an arc which heats the slag. The arc is then extinguished and the conductive slag is maintained in a molten condition by its resistance to electric current passing between the electrode and the work.

CONSUMABLE GUIDE ELECTROSLAG WELDING – A method of electroslag welding in which filler metal is supplied by an electrode and its guiding member.

FAYING SURFACE – The mating surface of a member which is in contact or in close proximity with another member to which it is to be joined.

FILLER METAL – The metal to be added in making a welded joint. See *electrode* and *welding rod.*

FLARE-BEVEL-GROOVE WELD – A weld in a groove formed by a member with a curved surface in contact with a planar member.

FLARE-V-GROOVE WELD – A weld in a groove formed by two members with curved surfaces.

FLASH – The material which is expelled or squeezed out of a weld joint and which forms around the weld.

FLAT POSITION – The welding position used to weld from the upper side of the joint and the face of the weld is approximately horizontal.

FLUX CORE ARC WELDING (FCAW) – An arc welding process which produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is provided by a flux contained within the electrode. Additional shielding may or may not be obtained from an externally supplied gas or gas mixture.

FUSION – The melting together of filler metal and base metal, or the melting of base metal only, which results in coalescence. See *depth of fusion*

FUSION TYPE DISCONTINUITY - Signifies slag inclusion, incomplete fusion, incomplete joint penetration, and similar discontinuities associated with fusion.

FUSION ZONE – The area of base metal melted as determined on the cross section of a weld.

GAS METAL ARC WELDING (GMAW) – An arc welding process which produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture. Some methods of this process are called MIG or C02 welding (nonpreferred terms).

GAS METAL ARC WELDING - SHORT CIRCUIT ARC (GMAW-S) – A gas metal arc welding process variation in which the consumable electrode is deposited during repeated short circuits. Sometimes this process is referred to as MIG or C02 welding (nonpreferred terms).

GAS POCKET – A cavity caused by entrapped gas.

GOUGING – The forming of a bevel or groove by material removal. See also *back gouging, arc gouging,* and *oxygen gouging.*

GROOVE ANGLE – The total included angle of the groove between parts to be joined by a groove weld.

GROOVE FACE – That surface of a member included in the groove.

GROOVE WELD – A weld made in the groove between two members to be joined.

HEAT-AFFECTED ZONE – That portion of the base metal which has not been melted, but whose mechanical properties or microstructure have been altered by the heat of welding, brazing, soldering, or cutting.

HORIZONTAL FIXED POSITION (PIPE WELDING) – The position of a pipe joint in which the axis of the pipe is approximately horizontal and the pipe is not rotated during welding.

HORIZONTAL POSITION - FILLET WELD – The position in which welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface.

HORIZONTAL POSITION - GROOVE WELD – The position of welding in which the axis of the weld lies in an approximately horizontal plane and the face of the weld lies in an approximately vertical plane.

HORIZONTAL ROTATED POSITION (PIPE WELDING) – The position of a pipe joint in which the axis of the pipe is approximately horizontal, and welding is performed in the flat position by rotating the pipe.

INERT GAS METAL ARC WELDING – See preferred term *gas metal arc welding.*

INTERMITTENT WELD – A weld in which the continuity is broken by recurring unwelded spaces.

INTERPASS TEMPERATURE – In a multiple-pass weld, the temperature (minimum or maximum as specified) of the deposited weld before the next pass is started.

JOIN – The junction of members of the edges of members that are to be joined or have been joined.

JOINT PENETRATION – The minimum depth of a groove or flange weld extends from its face into a joint exclusive of reinforcement. Joint penetration may include root penetration.

JOINT WELDING PROCEDURE – The materials and detailed methods and practices employed in the welding of a particular joint.

LAP JOINT – A joint between two overlapping members.

LAYER – A stratum of weld metal or surfacing material. The layer may consist of one or more welds beads laid side by side.

LEG OF A FILLET WELD – The distance from the root of the joint to the toe of the fillet weld.

MACHINE WELDING – Welding with equipment which performs the welding operation under the constant observation and control of an operator. The equipment may or may not perform the loading and unloading of the work. See *automatic welding.*

MANUAL WELDING – A welding operation performed and controlled completely by hand. See *automatic welding, machine welding, and semiautomatic welding.*

OVERHEAD POSITION – The position in which welding is performed from the underside of the joint.

OVERLAP – The protrusion of weld metal beyond the toe, face, or root of the weld.

OXYGEN CUTTING (OC) – A group of cutting processes used to sever or remove metals by means of the chemical reaction of oxygen with the base metal at elevated temperatures. In. the case of oxidation-resistant metals, the reaction is facilitated by the use of a chemical flux or metal powder.

OXYGEN GOUGING – An application of oxygen cutting in which a bevel or groove is formed.

PARALLEL ELECTRODE – See *submerged arc welding* (SAW).

PARTIAL JOINT PENETRATION – Joint penetration which is less than complete.

PASS – See preferred term *weld pass.*

PEENING – The mechanical working of metals using impact blows.

PIPE – Tubular-shaped product of circular cross section. See *tubular*

PIPING POROSITY (GENERAL) – Elongated porosity whose major dimension lies in a direction approximately normal to the weld surface. Frequently referred to as "pin holes" when the porosity extends to the weld surface.

PLUG WELD – A circular weld made through a hole in one member of a lap or T-joint fusing that member to the other. The walls of the hole may or may not be parallel and the hole may be partially or completely filled with weld metal. (A fillet welded hole or a spot weld should not be construed as conforming to this definition.

POROSITY – Cavity type discontinuities formed by gas entrapment during solidification.

POSITIONED WELD – A weld made in a joint which has been so placed as to facilitate making the weld.

POSTWELD HEAT TREATMENT – Any heat treatment subsequent to welding. PREHEATING. The application of heat to the base metal immediately before welding, brazing, soldering, or cutting.

PREHEAT TEMPERATURE – A specified temperature that the base metal must attain in the welding, brazing, soldering, or cutting area immediately before these operations are performed.

PROCEDURE QUALIFICATION – The demonstration that welds made by a specific procedure can meet prescribed standards.

QUALIFICATION – See preferred terms *welder performance qualification* and *procedure qualification.*

RANDOM SEQUENCE – See preferred term *wandering sequence.*

REINFORCEMENT OF WELD – Weld metal in excess of the quantity required to fill a joint.

REJECTABLE DISCONTINUITY – See preferred term *defect.*

ROOT FACE – That portion of the groove face adjacent to the root of the joint.

ROOT GAP – See preferred term *root opening.*

ROOT OF JOINT – That portion of a joint to be welded where the members approach closest to each other. In cross section, the root of the joint may be either a point, a line, or an area.

ROOT OF WELD – The points, as shown in cross section, at which the back of the weld intersects the base metal surfaces.

ROOT OPENING – The separation, at the root of the joint, between the members to be joined.

SEMIAUTOMATIC ARC WELDING – Arc welding with equipment which controls only the filler metal feed. The advance of the welding is manually controlled.

SHIELDED METAL ARC WELDING (SMAW) – An arc welding process which produces coalescence of metals by heating with an arc between a covered metal electrode and the work. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

SHIELDING GAS – Protective gas used to prevent atmospheric contamination.

SINGLE-WELDED JOINT – In arc and gas welding, any joint welded from one side only.

SIZE OF WELD:

> **GROOVE WELD –** The joint penetration (depth of bevel plus the root penetration when specified). The size of a groove weld and its effective throat are one and the same.
>
> **FILLET WELD –** *For equal leg fillet welds,* the leg length of the largest isosceles right triangle that can be inscribed within the fillet weld cross section. *For unequal leg fillet* welds, the length of the largest right triangle that can be inscribed within the fillet weld cross section.
>
> **NOTE:** When one member makes an angle with the other member greater than 105 degrees, the leg length (size) is of less significance than the effective throat which is the controlling factor for the strength of a weld.

SLOT WELD – A weld made in an elongated hole in one member of a lap or T-joint joining that member to that portion of the surface of the other member which is exposed through the hole. The hole may be open at one end and may be partially or completely filled with weld metal. (A fillet welded slot should not be construed as conforming to this definition.)

SPATTER – The metal particles expelled during welding; they do not form a part of the weld.

STRINGER BEAD – A type of weld bead made without appreciable weaving motion.

STUD ARC WELDING (SW) – An arc welding process which produces coalescence of metals by heating with an arc between a metal stud or similar part and the other work part. When the surfaces to be joined are properly heated, they are brought together under pressure. Partial shielding may be obtained by the use of a ceramic ferrule surrounding the stud. Shielding gas or flux may or may not be used.

SUBMERGED ARC WELDING (SAW) – An arc welding process which produces coalescence of metals by heating with an arc or arcs between a bare metal electrode or electrodes and the work. The arc is shielded by a blanket of granular, fusible material on the work. Pressure is not used and filler metal is obtained from the electrode and sometimes from a supplementary welding rod.

SINGLE ELECTRODE – One electrode connected exclusively to one power source which may consist of one or more power units.

PARALLEL ELECTRODE – Two electrodes connected electrically in parallel and exclusively to the same power source. Both electrodes are usually fed by means of a single electrode feeder. Welding current, when specified, is the total for the two electrodes.

MULTIPLE ELECTRODES – The combination of two or more parallel electrode systems. Each of the component systems has its own independent power source and its own electrode feeder.

TACK WELD – A weld made to hold parts of a weldment in proper alignment until the final welds are made.

TACKER – A fitter, or someone under the direction of a fitter, who tack welds parts of a weldment to hold them in proper alignment until the final welds are made.

TANDEM – Refers to a geometrical arrangement of electrodes in which a line through the arcs is parallel to the direction of welding.

TEMPORARY WELD – A weld made to attach a piece or pieces to a weldment for temporary use in handling, shipping, or working on the weldment.

THROAT OF A FILLET WELD:

> **ACTUAL THROAT –** The shortest distance from the root of a fillet weld to its face.
>
> **THEORETICAL THROAT –** The distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the fillet cross section.

THROAT OF A GROOVE WELD – See preferred term *size of weld.*

T-JOINT – A joint between two members located approximately at right angles to each other in the form of a T.

TOE OF WELD – The junction between the face of a weld and the base metal.

TRANSVERSE DISCONTINUITY – A weld discontinuity whose major dimension is in a direction perpendicular to the weld axis "X."

TUBULAR – Tubular products is a generic term for a family of hollow section products of various cross-sectional configuration. The term "pipe" denotes cylindrical products to differentiate from square and rectangular hollow section products. However, a tube or tubing can also be cylindrical. User should note the AISC designation of tubular sections: TSC x t for circular tubes (pipe) TSa x b x t for square and rectangular tubes (referred to collectively as box sections in Section 10) Where TS = the group symbol t nominal wall thickness D nominal outside diameter a nominal major width b nominal minor width

TUBULAR CONNECTION – A connection in the portion of a tubular structure which contains two or more intersecting tubular members.

TUBULAR JOINT – A joint in the interface created by one tubular member intersecting another.

UNDERCUT – A groove melted into the base metal adjacent to the toe or root of a weld and left unfilled by weld metal.

VERTICAL POSITION – The position of welding in which the axis of the weld is approximately vertical.

VERTICAL POSITION PIPE WELDING – The position of a pipe joint wherein welding is performed in the horizontal position and the pipe shall not be rotated during welding.

WANDERING SEQUENCE – A longitudinal sequence in which the weld bead increments are deposited at random.

WEAVE BEAD – A type of weld bead made with transverse oscillation.

WELD – A localized coalescence of metals produced either by heating to suitable temperatures, with or without the application of pressure or by the application of pressure alone, and with or without the use of filler metal.

WELDABILITY – The capacity of a metal to be welded under the fabrication conditions imposed into a specific suitably designed structure and to perform satisfactorily in the intended service.

WELD BEAD – A weld deposit resulting from a pass. See *stringer bead* and *weave bead.*

WELDER – One who performs a manual or semiautomatic welding operation.

WELDER CERTIFICATION – Certification in writing that a welder has produced welds meeting prescribed standards.

WELDER PERFORMANCE QUALIFICATION – The demonstration of a welder's ability to produce welds meeting prescribed standards.

WELDING – A metal joining process used in making welds.

WELDING MACHINE – Equipment used to perform the welding operation. For example, spot welding machine, arc welding machine, seam welding machine, etc.

WELDING OPERATOR – One who operates machine or automatic welding equipment.

WELDING PROCEDURE – The detailed methods and practices including all joint welding procedures involved in the production of a weldment. See *joint welding procedure.*

WELDING SEQUENCE – The order of making the welds in a weldment.

WELDMENT – An assembly whose component parts are joined by welding.

SAMPLE
WELDING PROCEDURE SPECIFICATION

PREQUALIFIED SMAW — WPS # WABO 201

Yes X No — Supporting PQR #

JOINT DESIGN USED

Type: Butt- Single-Vee

Single X Double ____

Backing: Yes X No ____

Material Type: Mild steel

Root Opening: 1/4" Root Face: N/A

Groove Angle: 45° Radius J-U: N/A

Back Gouging:

Yes ____ No X

Method: N/A

BASE METALS

Material Spec. Group I

Type or Grade: A36

Thickness:

Groove: 1" Fillet: ____

Diameter (Pipe):

FILLER METALS

AWS Specification: AWS A5.1

AWS Classification: E-7018

SHIELDING

Gas Type: N/A

Flow Rate: N/A

Gas Nozzle Size: N/A

PREHEAT

Preheat Temp., Min: 50°F Max: ____

Interpass Temp., Min: 50°F Max: ____

POSITION

Groove: 3G, 4G Fillet: ____

Vertical Progression:

Up X Down

ELECTRICAL CHARACTERISTICS

Transfer Mode (GMAW)

Short - Circuiting: ____

Globular: ____

Spray: ____

Current:

AC: ____

DCEP: X

DCEN: ____

Pulse

TECHNIQUE

Bead Type:

Stringer: X Weave: ____

Multi Pass: X

Single Pass: ____

Stick Out: N/A

Interpass Cleaning: Chip and wire brush.

POSTWELD HEAT TREATMENT

Temp.: N/A

Time.: N/A

BACK-BEAD N/A

WELDING PROCEDURE

PASS OR LAYERS	AMPS.	WIRE SPEED in/min
All	100-140	N/A

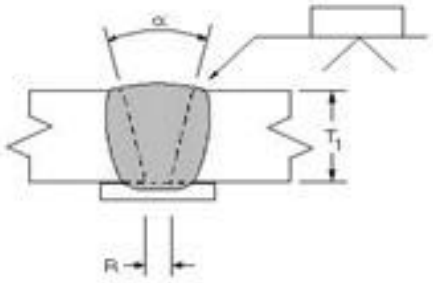
PROCESS
SMAW

FILLER METALS
E7018
1/8" dia.

CURRENT
DCEP

VOLTAGE
21-25

TRAVEL SPEED
6-12 IPM



JOINT DETAILS B-U2a — α = 45° T = 1" R = 1/4" maximum

SAMPLE
WELDING PROCEDURE SPECIFICATION

PREQUALIFIED FCAW — WPS # WABO 301

Yes X No — Supporting PQR #

JOINT DESIGN USED

Type: Butt- Single-Vee

Single X Double ____

Backing: Yes X No ____

Material Type: Mild steel

Root Opening Max.: 1/4" Root Face: N/A

Groove Angle: 45° Radius J-U: N/A

Back Gouging:

Yes ____ No X

Method: N/A

BASE METALS

Material Spec. Group I

Type or Grade: A36

Thickness:

Groove: 1" Fillet: ____

Diameter (Pipe)

FILLER METALS

AWS Specification: AWS A5.20

AWS Classification: E-71T-1

SHIELDING

Gas Type: 75% Ar, 25% Co2

Flow Rate: 30-70 CFH

Gas Nozzle Size: All

PREHEAT

Preheat Temp., Min: 50°F Max: ____

Interpass Temp., Min: 50°F Max: ____

POSITION

Groove: 3G, 4G Fillet: ____

Vertical Progression:

Up X Down

ELECTRICAL CHARACTERISTICS

Transfer Mode (GMAW)

Short - Circuiting: ____

Globular: ____

Spray: X

Current:

AC: ____

DCEP: X

DCEN: ____

Pulse

TECHNIQUE

Bead Type:

Stringer: X Weave: ____

Multi Pass: X

Single Pass: ____

Stick Out: 1/4" - 3/4"

Interpass Cleaning: Chip and wire brush.

POSTWELD HEAT TREATMENT

Temp.: N/A

Time.: N/A

BACK-BEAD N/A

WELDING PROCEDURE

PASS OR LAYERS
All

PROCESS
FCAW

FILLER METALS
E-71T-1
.052" - 1/16"

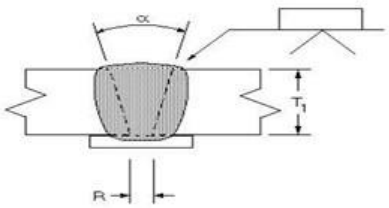
CURRENT
DCEP

WIRE SPEED in/min
150 - 320 ipm

VOLTAGE
23-28

TRAVEL SPEED
12 - 25 IPM

AMPS.
150-400



JOINT DETAILS α = 45° R = 1/4" maximum
B-U2a-GF T = 1"

SAMPLE
WELDING PROCEDURE SPECIFICATION

PREQUALIFIED GMAW — Yes X — No

WPS # WABO 401

Supporting PQR #

JOINT DESIGN USED

Type:	Butt-	Single-Vee		
Single	X	Double		
Backing:	Yes X		No	
Material Type	Mild steel			
Root Opening Max.	1/4"	Root Face	N/A	
Groove Angle	45°	Radius J-U	N/A	
Back Gouging:				
	Yes		No X	
Method	N/A			

BASE METALS

Material Spec.	Group I		
Type or Grade	A36		
Thickness:			
Groove	3/8"	Fillet	
Diameter (Pipe)			

FILLER METALS

AWS Specification	AWS A5.18
AWS Classification	E70S-3, E70S-4

SHIELDING

Gas Type	75% Ar, 25% Co2
Flow Rate	30-70 CFH
Gas Nozzle Size	All

PREHEAT

Preheat Temp., Min	50°F	Max	
Interpass Temp., Min	50°F	Max	

POSITION

Groove 3G, 4G — Fillet

Vertical Progression:

Up X — Down

ELECTRICAL CHARACTERISTICS

Transfer Mode (GMAW)

Short - Circuiting	X
Globular	X
Spray	X
Current:	
AC	
DCEP	X
DCEN	
Pulse	

TECHNIQUE

Bead Type:

Stringer	X	Weave	
Multi Pass	X		
Single Pass			
Stick Out	1/8" - 3/4"		
Interpass Cleaning	Chip and wire brush.		

POSTWELD HEAT TREATMENT

Temp.	N/A
Time.	N/A

BACK-BEAD N/A

WELDING PROCEDURE

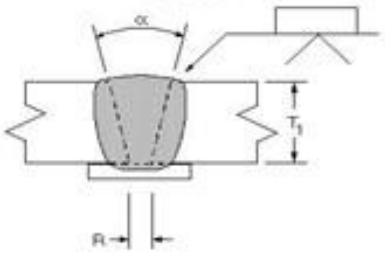
PASS OR LAYERS	WIRE SPEED in/min	AMPS.
All	100 - 400 ipm	100-300

PROCESS
GMAW

VOLTAGE
17-25

FILLER METALS
E70S-3, E70S-4
.035"

TRAVEL SPEED
6 - 18 ipm



CURRENT
DCEP

JOINT DETAILS
B-U2a-GF

α = 30° T = 3/8"
R = 1/4" maximum

SAMPLE WELDING PROCEDURE SPECIFICATION

Resticted Access Supplemental Welder Qualification Removable Backing

PREQUALIFIED

Yes X No

WABO WPS # 102-10

Supporting PQR # prequalified

JOINT DESIGN USED

Type: Butt- Bevel Groove

Single X Double

Backing: Yes X No

Material Type Ceramic / Copper

Root Opening 3/8 Root Face N/A

Groove Angle 30° Radius J-U N/A

Back Gouging:

Yes X No

Method CAC-A

BASE METALS

Material Spec. Group I

Type or Grade A36 / A572 grd 50

Thickness:

Groove 1" Fillet

Diameter (Pipe)

FILLER METALS

AWS Specification AWS A5.1

AWS Classification E7018

SHIELDING

Gas Type N/A

Flow Rate N/A

Gas Nozzle Size N/A

PREHEAT

Preheat Temp., Min 50°F Max

Interpass Temp., Min 50°F Max

POSITION Fillet

Groove 1G

Vertical Progression:

Up N/A Down N/A

ELECTRICAL CHARACTERISTICS

Transfer Mode (GMAW N/A

Short - Circuiting N/A

Globular N/A

Spray N/A

Current: DCEP

AC

DCEP X

DCEN

Pulse

TECHNIQUE

Bead Type:

Stringer X Weave N/A

Multi Pass X

Single Pass N/A

Stick Out N/A

Interpass Cleaning Chip and wire brush.

POSTWELD HEAT TREATMENT

Temp. N/A

Time. N/A

BACK-BEAD

Yes

Back-bead must be welded in the overhead position.

WELDING PROCEDURE

PASS OR LAYERS

All

WIRE SPEED in/min

N/A

AMPS.

180-300

PROCESS

SMAW

VOLTAGE

21-25

FILLER METALS

E7018

3/16" dia.

TRAVEL SPEED

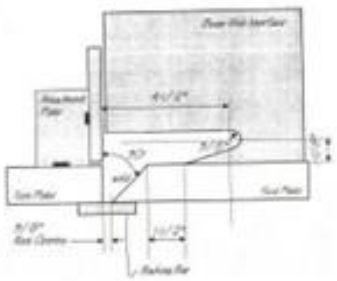
6-15 IPM

CURRENT

DCEP

JOINT DETAILS

B-U4a



SAMPLE WELDER QUALIFICATION PROCEDURE

Seismic Restricted Access Supplemental Welder Qualification

PREQUALIFIED

Yes X No

WABO WPS # 101-6

Supporting PQR # prequalified

JOINT DESIGN USED

Type: Butt- Bevel Groove

Single X Double ____

Backing: Yes X No ____

Material Type Mild Steel

Root Opening 3/8 Root Face N/A

Groove Angle 30° Radius J-U N/A

Back Gouging:

Yes ____ No X

Method

BASE METALS

Material Spec. Group I & II

Type or Grade A36 / A572 gr. 50

Thickness:

Groove 1" Fillet ____

Diameter (Pipe)

FILLER METALS

AWS Specification AWS A5.20

AWS Classification E71T-6

SHIELDING

Gas Type N/A

Flow Rate N/A

Gas Nozzle Size N/A

PREHEAT

Preheat Temp., Min 50°F Max ____

Interpass Temp., Min 50°F Max ____

POSITION

Groove 1G Fillet ____

Vertical Progression:

Up Down

TECHNIQUE

Bead Type:

Stringer X Weave ____

Multi Pass X

Single Pass ____

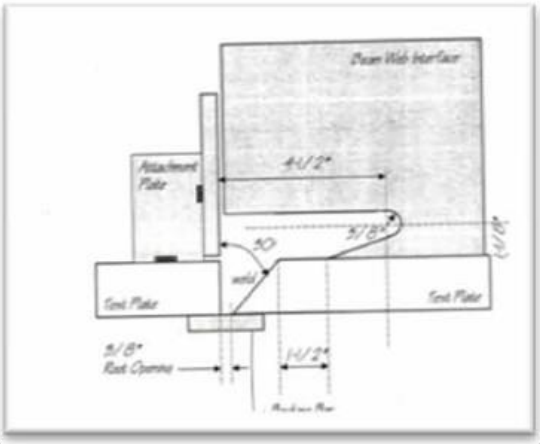
Stick Out 1"

Interpass Cleaning Chip and wire brush.

POSTWELD HEAT TREATMENT

Temp. N/A

Time. N/A



WELDING PROCEDURE

PASS OR LAYERS
All

WIRE SPEED in/min
200-400 imp

AMPS.
275-475

PROCESS
FCAW-S

VOLTAGE
23-27

FILLER METALS
E71T-6
5/64"

TRAVEL SPEED
15-30 ipm

CURRENT
DCEP

JOINT DETAILS
B-U4a-GF

SAMPLE WELDER QUALIFICATION PROCEDURE

Seismic Restricted Access Supplemental Welder Qualification

PREQUALIFIED

Yes X No

WABO WPS # 101-8

Supporting PQR # prequalified

JOINT DESIGN USED

Type: Butt- Bevel Groove

Single X Double ____

Backing: Yes X No ____

Material Type Mild Steel

Root Opening 3/8 Root Face N/A

Groove Angle 30° Radius J-U N/A

Back Gouging:

Yes ____ No X

Method

BASE METALS

Material Spec. Group I & II

Type or Grade A36 / A572 gr. 50

Thickness:

Groove 1" Fillet ____

Diameter (Pipe)

FILLER METALS

AWS Specification AWS A5.20

AWS Classification E71T-8 (ESAB Core Shield 8)

SHIELDING

Gas Type N/A

Flow Rate N/A

Gas Nozzle Size N/A

PREHEAT

Preheat Temp., Min 50°F Max ____

Interpass Temp., Min 50°F Max ____

POSITION

Groove 1G Fillet ____

Vertical Progression:

Up ____ Down ____

TECHNIQUE

Bead Type:

Stringer X Weave ____

Multi Pass X

Single Pass ____

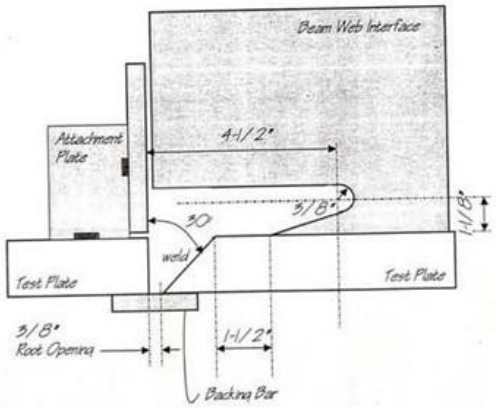
Stick Out 1/2" - 1"

Interpass Cleaning Chip and wire brush.

POSTWELD HEAT TREATMENT

Temp. N/A

Time. N/A



WELDING PROCEDURE

PASS OR LAYERS

All

PROCESS

FCAW-S

FILLER METALS

E71T-8 (ESAB Core Shield 8)
.072"

CURRENT

DCEN

WIRE SPEED in/min

230-290 ipm

AMPS.

340-380

VOLTAGE

23-25

TRAVEL SPEED

12-20 ipm

JOINT DETAILS

B-U4a-GF

SAMPLE WELDER QUALIFICATION PROCEDURE

Seismic Restricted Access Supplemental Welder Qualification
Removable Backing

PREQUALIFIED

Yes X No

WABO WPS # 102-6

Supporting PQR # prequalified

JOINT DESIGN USED

Type: Butt- Bevel Groove

Single X Double ____

Backing: Yes X No ____

Material Type Ceramic / Copper

Root Opening 3/8 Root Face N/A

Groove Angle 30° Radius J-U N/A

Back Gouging:

Yes X No ____

Method CAC-A

BASE METALS

Material Spec. Group I

Type or Grade A36 / A572 grd 50

Thickness:

Groove 1" Fillet ____

Diameter (Pipe)

FILLER METALS

AWS Specification AWS A5.20

AWS Classification E71T-6

SHIELDING

Gas Type N/A

Flow Rate N/A

Gas Nozzle Size N/A

PREHEAT

Preheat Temp., Min 50°F Max ____

Interpass Temp., Min 50°F Max ____

POSITION

Groove 1G Fillet ____

Vertical Progression:

Up ____ Down ____

TECHNIQUE

Bead Type:

Stringer X Weave ____

Multi Pass X

Single Pass ____

Stick Out 1"

Interpass Cleaning Chip and wire brush.

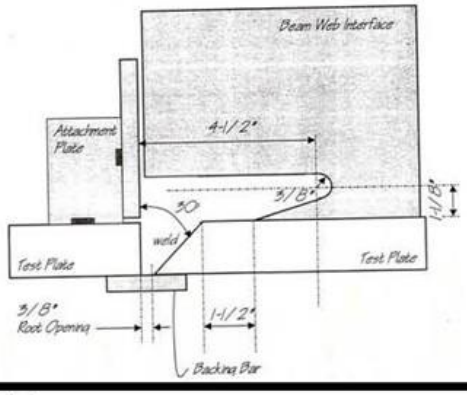
POSTWELD HEAT TREATMENT

Temp. N/A

Time. N/A

BACK-BEAD Back-bead must be welded

Process change OK in the overhead position.



WELDING PROCEDURE

PASS OR LAYERS
All

PROCESS
FCAW-S

FILLER METALS
E71T-6
5/64"

CURRENT
DCEP

WIRE SPEED in/min
200-400

VOLTAGE
23-27

TRAVEL SPEED
15-30

JOINT DETAILS
B-U4a-GF

AMPS.
275-475

SAMPLE WELDER QUALIFICATION PROCEDURE

Seismic Restricted Access Supplemental Welder Qualification
Removable Backing

PREQUALIFIED

Yes X No

WABO WPS # 102-8

Supporting PQR # prequalified

JOINT DESIGN USED

Type:	Butt- Bevel Groove		
Single	X	Double	
Backing:	Yes X	No	
Material Type	Ceramic / Copper		
Root Opening	3/8	Root Face	N/A
Groove Angle	30°	Radius J-U	N/A
Back Gouging:	Yes: X	No	
Method	CAC-A		

BASE METALS

Material Spec.	Group I		
Type or Grade	A36 / A572 grd 50		
Thickness:			
Groove	1"	Fillet	
Diameter (Pipe)			

FILLER METALS

AWS Specification	AWS A5.20
AWS Classification	E71T-8 (ESAB Core Shield 8)

SHIELDING

Gas Type	N/A
Flow Rate	N/A
Gas Nozzle Size	N/A

PREHEAT

Preheat Temp., Min	50°F	Max	
Interpass Temp., Min	50°F	Max	

POSITION

	Groove 1G	Fillet	
Vertical Progression:			
	Up	Down	

TECHNIQUE

Bead Type:			
	Stringer X	Weave	
	Multi Pass X		
	Single Pass		
	Stick Out 1/2-1"		
Interpass Cleaning	Chip and wire brush.		

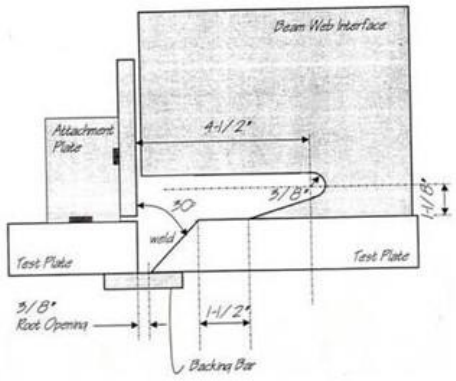
POSTWELD HEAT TREATMENT

Temp.	N/A
Time.	N/A

BACK-BEAD

Back-bead must be welded in the overhead position.

Process change OK



WELDING PROCEDURE

PASS OR LAYERS
All

WIRE SPEED in/min
230-290 ipm

AMPS.
340-380

PROCESS
FCAW-S

VOLTAGE
23-25

FILLER METALS
E71T-8 (ESAB Core Shield 8)
.072"

TRAVEL SPEED
12-20 ipm

CURRENT
DCEN

JOINT DETAILS
B-U4a-GF