7. Stud Welding

7.1 Scope

Section 7 contains general requirements for welding of steel studs to steel, and stipulates specific requirements:

(1) For workmanship, preproduction testing, operator qualification, and application qualification testing when required, all to be performed by the Contractor

(2) For fabrication/erection and verification inspection of stud welding during production

(3) For mechanical properties of steel studs, and requirements for qualification of stud bases, all tests and documentation to be furnished by the stud manufacturer

Note: Approved steels; for studs, see 7.2.6; for base metals, see Table 3.1 (Groups I and II). For guidance, see C7.6.1.

7.2 General Requirements

7.2.1 Stud Design. Studs shall be of suitable design for arc welding to steel members with the use of automatically timed stud welding equipment. The type and size of the stud shall be as specified by the drawings, specifications, or special provisions. For headed-type studs, see Figure 7.1. Alternative head configurations may be used with proof of mechanical and embedment tests confirming full-strength development of the design, and with the approval of the Engineer.

7.2.2 Arc Shields. An arc shield (ferrule) of heat-resistant ceramic or other suitable material shall be furnished with each stud.

7.2.3 Flux. A suitable deoxidizing and arc stabilizing flux for welding shall be furnished with each stud of 5/16 in. [8 mm] diameter or larger. Studs less than 5/16 in. [8 mm] in diameter may be furnished with or without flux.

7.2.4 Stud Bases. A stud base, to be qualified, shall have passed the test described in Annex G. Only studs with qualified stud bases shall be used. Qualification of stud bases in conformance with Annex G shall be at the manufacturer's expense. The arc shield used in production shall be the same as used in qualification tests or as recommended by the manufacturer. When requested by the Engineer, the Contractor shall provide the following information:

(1) A description of the stud and arc shield

(2) Certification from the manufacturer that the stud base is qualified in conformance with Annex G.

(3) Qualification tests data

7.2.5 Stud Finish. Finish shall be produced by heading, rolling, or machining. Finished studs shall be of uniform quality and condition, free of injurious laps, fins, seams, cracks, twists, bends, or other injurious discontinuities. Radial cracks or bursts in the head of a stud shall not be the cause for rejection, provided that the cracks or bursts do not extend more than half the distance from the head periphery to the shank, as determined by visual inspection. Heads of shear connectors or anchor studs are subject to cracks or bursts, which are names for the same thing. Cracks or bursts designate an abrupt interruption of the periphery of the stud head by radial separation of the metal. Radial cracks or bursts in the head of a stud shall not be cause for rejection, provided that the cracks or bursts, as determined by visual inspection, do not exceed the value: 0.25 (H-C) (see Figure 7.1).

7.2.6 Stud Material. Studs shall be made from cold drawn bar stock conforming to the requirements of ASTM A 108, Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality Grades 1010 through 1020, inclusive either semi-killed or killed aluminum or silicon deoxidation.

7.2.7 Base Metal Thickness. When welding directly to base metal, the base metal shall be no thinner than 1/3 the stud diameter. When welding through deck, the stud diameter shall be no greater than 2.5 times the base material thickness. In no case shall studs be welded through more than two plies of metal decking.

7.3 Mechanical Requirements

7.3.1 Standard Mechanical Requirements. At the manufacturer's option, mechanical properties of studs shall be determined by testing either the steel after cold finishing or the full diameter finished studs. In either case, the studs shall conform to the standard properties shown in Table 7.1.

7.3.2 Testing. Mechanical properties shall be determined in conformance with the applicable sections of ASTM A 370, *Mechanical Testing of Steel Products*. A typical test fixture is used, similar to that shown in Figure 7.2.

7.3.3 Engineer's Request. Upon request by the Engineer, the Contractor shall furnish:

(1) The stud manufacturer's certification that the studs, as delivered, conform to the applicable requirements of 7.2 and 7.3.

(2) Certified copies of the stud manufacturer's test reports covering the last completed set of in-plant quality control mechanical tests, required by 7.3 for each diameter delivered. The quality control test shall have been made within the six month period before delivery of the studs.

(3) Certified material test reports (CMTR) from the steel supplier indicating diameter, chemical properties, and grade on each heat number delivered.

7.3.4 Absence of Quality Control Tests. When quality control tests are not available, the Contractor shall furnish a chemical test report conforming to 7.2.6 and a mechanical test report conforming to the requirements of 7.3 for each lot number. Unidentified and untraceable studs shall not be used.

7.3.5 Additional Studs. The Contractor is responsible for furnishing additional studs of each type and size, at the request of the Engineer, for checking the requirements of 7.2 and 7.3. Testing shall be at the owner's expense.

7.4 Workmanship

7.4.1 Cleanliness. At the time of welding, the studs shall be free from rust, rust pits, scale, oil, moisture, or other deleterious matter that would adversely affect the welding operation.

7.4.2 Coating Restrictions. The stud base shall not be painted, galvanized, or cadmium-plated prior to welding.

7.4.3 Base-Metal Preparation. The areas to which the studs are to be welded shall be free of scale, rust, moisture, paint, or other injurious material to the extent necessary to obtain satisfactory welds and prevent objectionable fumes. These areas may be cleaned by wire brushing, scaling, prick-punching, or grinding.

7.4.4 Moisture. The arc shields or ferrules shall be kept dry. Any arc shields which show signs of surface moisture from dew or rain shall be oven dried at 250°F [120°C] for two hours before use.

7.4.5 Spacing Requirements. Longitudinal and lateral spacings of stud shear connectors (type B) may vary a maximum of 1 in. [25 mm] from the location shown in the drawings. The minimum distance from the edge of a stud base to the edge of a flange shall be the diameter of the stud plus 1/8 in. [3 mm], but preferably not less than 1-1/2 in. [40 mm].

7.4.6 Arc Shield Removal. After welding, arc shields shall be broken free from studs to be embedded in concrete, and, where practical, from all other studs.

7.4.7 Acceptance Criteria. The studs, after welding, shall be free of any discontinuities or substances that would interfere with their intended function and have a full 360° flash. However, nonfusion on the legs of the flash and small shrink fissures shall be acceptable. The fillet weld profiles shown in Figure 5.4 shall not apply to the flash of automatically timed stud welds.

7.5 Technique

7.5.1 Automatic Machine Welding. Studs shall be welded with automatically timed stud welding equipment connected to a suitable source of direct current electrode negative power. Welding voltage, current, time, and gun settings for lift and plunge should be set at optimum settings, based on past practice, recommendations of stud and equipment manufacturer, or both. AWS C5.4, *Recommended Practices for Stud Welding*, should also be used for technique guidance.

7.5.2 Multiple Welding Guns. If two or more stud welding guns shall be operated from the same power source, they shall be interlocked so that only one gun can operate at a time, and so that the power source has fully recovered from making one weld before another weld is started.

7.5.3 Movement of Welding Gun. While in operation, the welding gun shall be held in position without movement until the weld metal has solidified.

7.5.4 Ambient and Base-Metal Temperature Requirements. Welding shall not be done when the base metal temperature is below 0°F [–18°C] or when the surface is wet or exposed to falling rain or snow. When the temperature of the base metal is below 32°F [0°C], one additional stud in each 100 studs welded shall be tested by methods described in 7.7.1.3 and 7.7.1.4, except that

the angle of testing shall be approximately 15°. This is in addition to the first two studs tested for each start of a new production period or change in set-up. Set-up includes stud gun, power source, stud diameter, gun lift and plunge, total welding lead length, and changes greater than ± 5% in current (amperage) and time.

7.5.5 FCAW, GMAW, SMAW Fillet Weld Option. At the option of the Contractor, studs may be welded using prequalified FCAW, GMAW, or SMAW processes, provided the following requirements are met:

7.5.5.1 Surfaces. Surfaces to be welded and surfaces adjacent to a weld shall be free from loose or thick scale, slag, rust, moisture, grease, and other foreign material that would prevent proper welding or produce objectionable fumes.

7.5.5.2 Stud End. For fillet welds, the end of the stud shall also be clean.

7.5.5.3 Stud Fit (Fillet Welds). For fillet welds, the stud base shall be prepared so that the base of the stud fits against the base metal.

7.5.5.4 Fillet Weld Minimum Size. When fillet welds shall be used, the minimum size shall be the larger of those required in Table 5.8 or Table 7.2.

7.5.5.5 Preheat Requirements. The base metal to which studs are welded shall be preheated in conformance with the requirements of Table 3.2.

7.5.5.6 SMAW Electrodes. SMAW welding shall be performed using low-hydrogen electrodes 5/32 in. or 3/16 in. [4.0 mm or 4.8 mm] in diameter, except that a smaller diameter electrode may be used on studs 7/16 in. [11.1 mm] or less in diameter for out-of-position welds.

7.5.5.7 Visual Inspection. FCAW, GMAW, and SMAW welded studs shall be visually inspected in conformance with 6.6.1.

7.6 Stud Application Qualification Requirements

When studs are to be welded through decking, the stud base qualification test shall include decking representative of that used in construction.

7.6.1 Purpose. Studs which are shop or field applied in the flat (down-hand) position to a planar and horizontal surface shall be considered prequalified by virtue of the manufacturer's stud base qualification tests (Annex G), and no further application testing shall be required. The limit of flat position is defined as 0°–15° slope on the surface to which the stud is applied. Some nonprequalified stud applications that require tests of this section are the following:

(1) Studs which are applied on nonplanar surfaces or to a planar surface in the vertical or overhead positions.

(2) Studs which are welded through decking. The tests shall be with material representative of the condition to be used in construction.

(3) Studs welded to other than Groups I or II steels listed in Table 3.1.

7.6.2 Responsibilities for Tests. The Contractor or stud applicator shall be responsible for the performance of these tests. Tests may be performed by the Contractor or stud applicator, the stud manufacturer, or by another testing agency satisfactory to all parties involved.

7.6.3 Preparation of Specimens

7.6.3.1 Test Specimens. To qualify applications involving materials listed in Table 3.1, Groups I and II: specimens may be prepared using ASTM A 36 steel base materials or base materials listed in Table 3.1, Groups I and II.

7.6.3.2 Recorded Information. To qualify applications involving materials other than those listed in Table 3.1, Groups I and II, the test specimen base material shall be of the chemical, physical and grade specifications to be used in production.

7.6.4 Number of Specimens. Ten specimens shall be welded consecutively using recommended procedures and settings for each diameter, position, and surface geometry.

7.6.5 Test Required. The ten specimens shall be tested using one or more of the following methods: bending, torquing, or tensioning.

7.6.6 Test Methods

7.6.6.1 Bend Test. Studs shall be tested by alternately bending 30° in opposite directions in a typical test fixture as shown in Annex G, Figure G.1 until failure occurs. Alternatively, studs may be bent 90° from their original axis. Type C studs, when bent 90°, shall be bent over a pin with a diameter of 4 times the diameter of the stud. In either case, a stud application shall be considered qualified if the studs are bent 90° and fracture occurs in the plate or shape material or in the shank of the stud and not in the weld.

7.6.6.2 Torque Test. Studs shall be torque tested using a torque test arrangement that is substantially in conformance with Figure 7.3. A stud application shall be considered qualified if all test specimens are torqued to destruction without failure in the weld.

7.6.6.3 Tension Test. Studs shall be tension tested to destruction using any machine capable of supplying the

required force. A stud application shall be considered qualified if the test specimens do not fail in the weld.

7.6.7 Application Qualification Test Data. Application Qualification Test Data shall include the following:

(1) Drawings that show shapes and dimensions of studs and arc shields.

(2) A complete description of stud and base materials, and a description (part number) of the arc shield.

(3) Welding position and settings (current, time).

(4) A record, which shall be made for each qualification and shall be available for each contract. A suggested WPS/PQR form for nonprequalified application may be found in Annex N.

7.7 Production Control

7.7.1 Pre-Production Testing

7.7.1.1 Start of Shift. Before production welding with a particular set-up and with a given size and type of stud, and at the beginning of each day's or shift's production, testing shall be performed on the first two studs that are welded. The stud technique may be developed on a piece of material similar to the production member in thickness and properties. If actual production thickness is not available, the thickness may vary ± 25%. All test studs shall be welded in the same general position as required on the production member (flat, vertical, or overhead).

7.7.1.2 Production Member Option. Instead of being welded to separate material, the test studs may be welded on the production member, except when separate plates are required by 7.7.1.5.

7.7.1.3 Flash Requirement. The test studs shall be visually examined. They shall exhibit full 360° flash with no evidence of undercut into the stud base.

7.7.1.4 Bending. In addition to visual examination, the test shall consist of bending the studs after they are allowed to cool, to an angle of approximately 30° from their original axes by either striking the studs with a hammer on the unwelded end or placing a pipe or other suitable hollow device over the stud and manually or mechanically bending the stud. At temperatures below 50°F [10°C], bending shall preferably be done by continuous slow application of load. For threaded studs, the torque test of Figure 7.3 shall be substituted for the bend test.

7.7.1.5 Event of Failure. If on visual examination the test studs do not exhibit 360° flash, or if on testing, failure occurs in the weld zone of either stud, the procedure shall be corrected, and two more studs shall be welded to separate material or on the production member and tested in conformance with the provisions of 7.7.1.3 and 7.7.1.4. If either of the second two studs fails, additional welding shall be continued on separate plates until two consecutive studs are tested and found to be satisfactory before any more production studs are welded to the member.

7.7.2 Production Welding. Once production welding has begun, any changes made to the welding setup, as determined in 7.7.1, shall require that the testing in 7.7.1.3 and 7.7.1.4 be performed prior to resuming production welding.

7.7.3 Repair of Studs. In production, studs on which a full 360° flash is not obtained may, at the option of the Contractor, be repaired by adding the minimum fillet weld as required by 7.5.5 in place of the missing flash. The repair weld shall extend at least 3/8 in. [10 mm] beyond each end of the discontinuity being repaired.

7.7.4 Operator Qualification. The pre-production test required by 7.7.1, if successful, shall also serve to qualify the stud welding operator. Before any production studs are welded by an operator not involved in the pre-production set-up of 7.7.1, the first two studs welded by the operator shall have been tested in conformance with the provisions of 7.7.1.3 and 7.7.1.4. When the two welded studs have been tested and found satisfactory, the operator may then weld production studs.

7.7.5 Removal Area Repair. If an unacceptable stud has been removed from a component subjected to tensile stresses, the area from which the stud was removed shall be made smooth and flush. Where in such areas the base metal has been pulled out in the course of stud removal, SMAW with low-hydrogen electrodes in conformance with the requirements of this code shall be used to fill the pockets, and the weld surface shall be flush.

In compression areas of members, if stud failures are confined to shanks or fusion zones of studs, a new stud may be welded adjacent to each unacceptable area in lieu of repair and replacement on the existing weld area (see 7.4.5). If base metal is pulled out during stud removal, the repair provisions shall be the same as for tension areas except that when the depth of discontinuity is the lesser of 1/8 in. [3 mm] or 7% of the base metal thickness, the discontinuity may be faired by grinding in lieu of filling with weld metal. Where a replacement stud is to be provided, the base metal repair shall be made prior to welding the replacement stud. Replacement studs (other than threaded type which should be torque tested) shall be tested by bending to an angle of approximately 15° from their original axes. The areas of components exposed to view in completed structures shall be made smooth and flush where a stud has been removed.

7.8 Fabrication and Verification Inspection Requirements

7.8.1 Visual Inspection. If a visual inspection reveals any stud that does not show a full 360° flash or any stud that has been repaired by welding, such stud shall be bent to an angle of approximately 15° from its original axis. Threaded studs shall be torque tested. The method of bending shall be in conformance with 7.7.1.4. The direction of bending for studs with less than a 360° flash shall be opposite to the missing portion of the flash. Torque testing shall be in conformance with Figure 7.3.

7.8.2 Additional Tests. The Verification Inspector, where conditions warrant, may select a reasonable number of additional studs to be subjected to the tests described in 7.8.1.

7.8.3 Bent Stud Acceptance Criteria. The bent stud shear connectors (Type B) and deformed anchors (Type C) and other studs to be embedded in concrete (Type A) that show no sign of failure shall be acceptable for use and left in the bent position. When bent studs are required by the contract documents to be straightened, the straightening operation shall be done without heating, and before completion of the production stud welding operation.

7.8.4 Torque Test Acceptance Criteria. Threaded studs (Type A) torque tested to the proof load torque level in Figure 7.3 that show no sign of failure shall be acceptable for use.

7.8.5 Engineering Judgment. If, in the judgment of the Engineer, studs welded during the progress of the work are not in conformance with code provisions, as indicated by inspection and testing, corrective action shall be required of the Contractor. At the Contractor's expense, the Contractor shall make the set-up changes necessary to ensure that studs subsequently welded will meet code requirements.

7.8.6 Owner's Option. At the option and the expense of the owner, the Contractor may be required, at any time, to submit studs of the types used under the contract for a qualification check in conformance with the procedures of Annex G.

Table 7.1
Mechanical Property Requirements for Studs (see 7.3.1)

		Type A[a]	Type B[b]	Type C[c]
Tensile strength	psi min	61 000	65 000	80 000
	MPa min	420	450	552
Yield strength (0.2% offset)	psi min	49 000	51 000	—
	MPa min	340	350	
(0.5% offset)	psi min	—	—	70 000
	MPa min			485
Elongation	% in 2 in. min	17%	20%	—
	% in 5x dia. min	14%	15%	
Reduction of area	% min	50%	50%	—

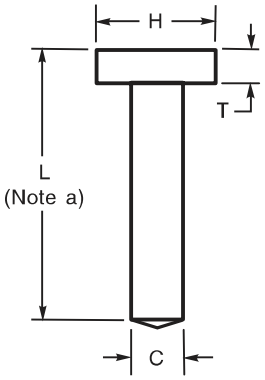
[a] Type A studs shall be general purpose of any type and size used for purposes other than shear transfer in composite beam design and construction.

[b] Type B studs shall be studs that are headed, bent, or of other configuration in 3/8 in. (10 mm), 1/2 in. [12 mm], 5/8 in. [16 mm], 3/4 in. [20 mm], 7/8 in. [22 mm], and 1 in. [25 mm] diameter that are used as an essential component in composite beam design and construction.

[c] Type C studs shall be cold-worked deformed steel bars manufactured in conformance with specification ASTM A 496 having a nominal diameter equivalent to the diameter of a plain wire having the same weight per foot as the deformed wire. ASTM A 496 specifies a maximum diameter of 0.628 in. [16 mm] maximum. Any bar supplied above that diameter shall have the same physical characteristics regarding deformations as required by ASTM A 496.

Table 7.2
Minimum Fillet Weld Size for Small Diameter Studs (see 7.5.5.4)

Stud Diameter		Min Size Fillet	
in.	mm	in.	mm
1/4 thru 7/16	6 thru 11	3/16	5
1/2	12	1/4	6
5/8, 3/4, 7/8	16, 20, 22	5/16	8
1	25	3/8	10



[a] Manufactured length before welding.

Standard Dimensions, in.				
Shank Diameter (C)		Length Tolerances (L)	Head Diameter (H)	Minimum Head Height (T)
1/2	+0.000 –0.010	± 1/16	1 ± 1/64	9/32
5/8	+0.000 –0.010	± 1/16	1-1/4 ± 1/64	9/32
3/4	+0.000 –0.015	± 1/16	1-1/4 ± 1/64	3/8
7/8	+0.000 –0.015	± 1/16	1-3/8 ± 1/64	3/8
1	+0.000 –0.015	± 1/16	1-5/8 ± 1/64	1/2
Standard Dimensions, mm				
12.7	+0.00 –0.25	± 1.6	25.4 ± 0.4	7.1
15.9	+0.00 –0.25	± 1.6	31.7 ± 0.4	7.1
19.0	+0.00 –0.38	± 1.6	31.7 ± 0.4	9.5
22.1	+0.00 –0.38	± 1.6	34.9 ± 0.4	9.5
25.4	+0.00 –0.38	± 1.6	41.3 ± 0.4	12.7

Figure 7.1—Dimension and Tolerances of Standard-Type Shear Connectors (see 7.2.1)

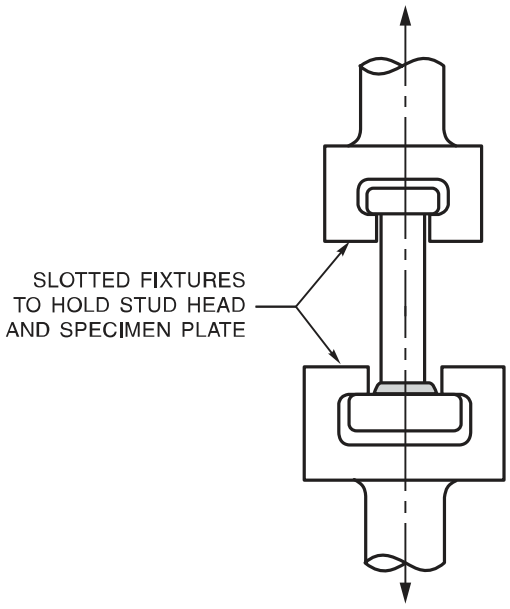
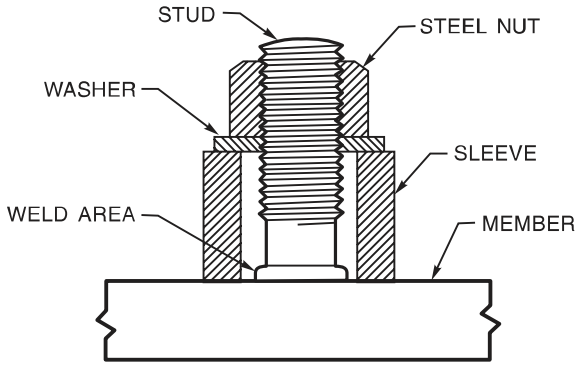


Figure 7.2—Typical Tension Test Fixture (see 7.3.2)



Note: Dimensions of test fixture details should be appropriate to the size of the stud. The threads of the stud shall be clean and free of lubricant other than the residue of cutting/cold forming lubricants in the "as received" condition from the manufacturer.

Required Proof Torque for Testing Threaded Studs[a]								
Nominal Diameter		M.E.T.A.[b]		Thread			Proof Testing Torque[c]	
in.	mm	sq. in.	sq. mm	no./in.	pitch-mm	Series	lb-ft	Joule
0.236	M6	0.031	20.1		1.0	ISO-724	5.4	7.4
1/4	6.4	0.036	23.2	28		UNF	6.6	9.0
		0.032	20.6	20		UNC	5.9	7.8
5/16	7.9	0.058	37.4	24		UNF	13.3	18.1
		0.052	33.5	18		UNC	11.9	16.1
0.315	M8	0.057	36.6		1.25	ISO-724	13.2	17.9
3/8	9.5	0.088	56.8	24		UNF	24.3	32.9
		0.078	50.3	16		UNC	21.5	29.2
0.394	M10	0.090	58.0		1.5	ISO-724	26.2	35.5
7/16	11.1	0.118	76.1	20		UNF	37.9	51.4
		0.106	68.4	14		UNC	34.8	47.2
0.472	M12	0.131	84.3		1.75	ISO-724	45.7	61.9
1/2	12.7	0.160	103.2	20		UNF	58.8	79.7
		0.142	91.6	13		UNC	52.2	70.8
0.551	M14	0.178	115.0		2.0	ISO-724	72.7	98.5
9/16	14.3	0.203	131.0	18		UNF	83.9	113.8
		0.182	117.4	12		UNC	75.2	102.0
5/8	15.9	0.255	164.5	18		UNF	117.1	158.8
		0.226	145.8	11		UNC	103.8	140.8
0.630	M16	0.243	157.0		2.0	ISO-724	113.4	153.7
3/4	19.1	0.372	240.0	16		UNF	205.0	278.0
		0.334	215.5	10		UNC	184.1	249.7
0.787	M20	0.380	245.0		2.5	ISO-724	221.2	299.9
0.866	M22	0.470	303.0		2.5	ISO-724	300.9	408.0
7/8	22.2	0.509	328.4	14		UNF	327.3	443.9
		0.462	298.1	9		UNC	297.1	402.9
0.945	M24	0.547	353.0		3.0	ISO-724	382.4	518.5
1	25.4	0.678	437.4	12		UNF	498.3	675.7
		0.606	391.0	8		UNC	445.4	604.0

[a] Torque figures are based on Type A threaded studs with a minimum yield stress of 49 000 psi (340 MPa).
[b] Mean Effective Thread Area (M.E.T.A) shall be defined as the effective stress area based on a mean diameter taken approximately midway between the minor and the pitch diameters.
[c] Values are calculated on a proof testing torque of 0.9 times Nominal Stud Diameter times 0.2 Friction Coefficient Factor times Mean Effective Thread Area times Minimum Yield Stress for unplated studs in the as-received condition. Plating, coatings, or oil/grease deposits will change the Friction Coefficient Factor.

Figure 7.3—Torque Testing Arrangement and Table of Testing Torques (see 7.6.6.2)

Annex G (Normative)

Manufacturers' Stud Base Qualification Requirements

This annex is a part of AWS D1.1/D1.1M:2006, *Structural Welding Code—Steel*, and includes mandatory elements for use with this standard.

G1. Purpose

The purpose of these requirements is to prescribe tests for the stud manufacturers' certification of stud base weldability.

G2. Responsibility for Tests

The stud manufacturer shall be responsible for the performance of the qualification test. These tests may be performed by a testing agency satisfactory to the Engineer. The agency performing the tests shall submit a certified report to the manufacturer of the studs giving procedures and results for all tests including the information described in G10.

G3. Extent of Qualification

Qualification of a stud base shall constitute qualification of stud bases with the same geometry, flux, and arc shield, having the same diameter and diameters that are smaller by less than 1/8 in. [3 mm]. A stud base qualified with an approved grade of ASTM A 108 steel shall constitute qualification for all other approved grades of ASTM A 108 steel (see 7.2.6), provided that conformance with all other provisions stated herein shall be achieved.

G4. Duration of Qualification

A size of stud base with arc shield, once qualified, shall be considered qualified until the stud manufacturer makes any change in the stud base geometry, material, flux, or arc shield which affects the welding characteristics.

G5. Preparation of Specimens

G5.1 Test specimens shall be prepared by welding representative studs to suitable specimen plates of ASTM A 36 steel or any of the other materials listed in Table 3.1 or Table 4.9. Studs to be welded through metal decking shall have the weld base qualification testing done by welding through metal decking representative of that used in construction, galvanized per ASTM A 653 coating designation G90 for one thickness of deck or G60 for two deck plies. When studs are to be welded through decking, the stud base qualification test shall include decking representative of that to be used in construction. Welding shall be done in the flat position (plate surface horizontal). Tests for threaded studs shall be on blanks (studs without threads).

G5.2 Studs shall be welded with power source, welding gun, and automatically controlled equipment as recommended by the stud manufacturer. Welding voltage, current, and time (see G6) shall be measured and recorded for each specimen. Lift and plunge shall be at the optimum setting as recommended by the manufacturer.

G6. Number of Test Specimens

G6.1 For studs 7/8 in. [22 mm] or less in diameter, 30 test specimens shall be welded consecutively with constant optimum time, but with current 10% above optimum. For studs over 7/8 in. [22 mm] diameter, 10 test specimens shall be welded consecutively with constant optimum time. Optimum current and time shall be the midpoint of the range normally recommended by the manufacturer for production welding.

G6.2 For studs 7/8 in. [22 mm] or less in diameter, 30 test specimens shall be welded consecutively with constant optimum time, but with current 10% below optimum. For studs over 7/8 in. [22 mm] diameter, 10 test specimens shall be welded consecutively with constant optimum time, but with current 5% below optimum.

G6.3 For studs to be welded through metal deck, the range of weld base diameters shall be qualified by welding 10 studs at the optimum current and time as recommended by the manufacturer conforming to the following:

(1) Maximum and minimum diameters welded through one thickness of 16 gage deck, coating designation G90.

(2) Maximum and minimum diameters welded through two plies of 16 gage deck coating designation G60.

(3) Maximum and minimum diameters welded through one thickness of 18 gage G60 deck over one thickness of 16 gage G60 deck.

(4) Maximum and minimum diameters welded through two plies of 18 gage deck, both with G60 coating designation.

The range of diameters from maximum to minimum welded through two plies of 18 gage metal deck with G60 galvanizing shall be qualified for welding through one or two plies of metal deck 18 gage or less in thickness.

G7. Tests

G7.1 Tension Tests. Ten of the specimens welded in conformance with G6.1 and ten in conformance with G6.2 shall be subjected to a tension test in a fixture similar to that shown in Figure 7.2, except that studs without heads may be gripped on the unwelded end in the jaws of the tension testing machine. A stud base shall be considered as qualified if all test specimens have a tensile strength equal to or above the minimum described in 7.3.1.

G7.2 Bend Tests (Studs 7/8 in. [22 mm] or less in diameter). Twenty of the specimens welded in conformance with G6.1 and twenty in conformance with G6.2 shall be bend tested by being bent alternately 30° from their original axes in opposite directions until failure occurs. Studs shall be bent in a bend testing device as shown in Figure G.1, except that studs less than 1/2 in. [12 mm] diameter may be bent using a device as shown in Figure G.2. A stud base shall be considered as qualified if, on all test specimens, fracture occurs in the plate material or shank of the stud and not in the weld or HAZ. All test specimens for studs over 7/8 in. [22 mm] shall only be subjected to tensile tests.

G7.3 Weld through Deck Tests. All 10 of the welds through deck stud specimens shall be tested by bending 30° in opposite directions in a bend testing device as shown in Figure G.1, or by bend testing 90° from their original axis or tension testing to destruction in a machine capable of supplying the required force. With any test method used, the range of stud diameters from maximum to minimum shall be considered as qualified weld bases for through deck welding if, on all test specimens, fracture occurs in the plate material or shank of the stud and not in the weld or HAZ.

G8. Retests

If failure occurs in a weld or the HAZ in any of the bend test groups of G7.2 or at less than specified minimum tensile strength of the stud in any of the tension groups in G7.1, a new test group (described in G6.1 or G6.2, as applicable) shall be prepared and tested. If such failures are repeated, the stud base shall fail to qualify.

G9. Acceptance

For a manufacturer's stud base and arc shield combination to be qualified, each stud of each group of 30 studs shall, by test or retest, meet the requirements described in G7. Qualification of a given diameter of stud base shall be considered qualification for stud bases of the same nominal diameter (see G3, stud base geometry, material, flux, and arc shield).

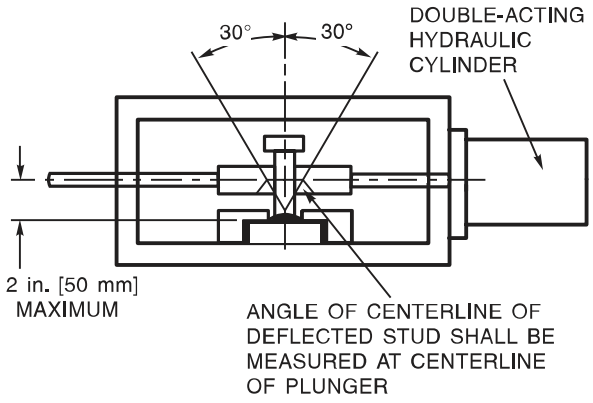
G10. Manufacturer's Qualification Test Data

The test data shall include the following:

(1) Drawings showing shapes and dimensions with tolerances of stud, arc shields, and flux

(2) A complete description of materials used in the studs, including the quantity and type of flux, and a description of the arc shields

(3) Certified results of laboratory tests required.



Notes:
1. Fixture holds specimen and stud is bent 30° alternately in opposite directions.
2. Load can be applied with hydraulic cylinder (shown) or fixture adapted for use with tension test machine.

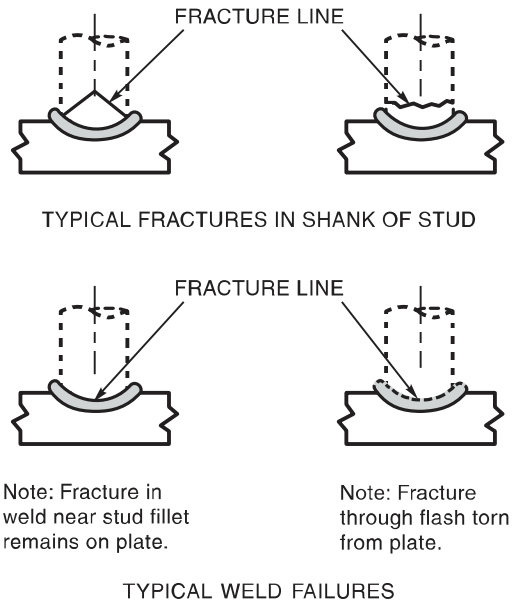


Figure G.1—Bend Testing Device (see G7.2)

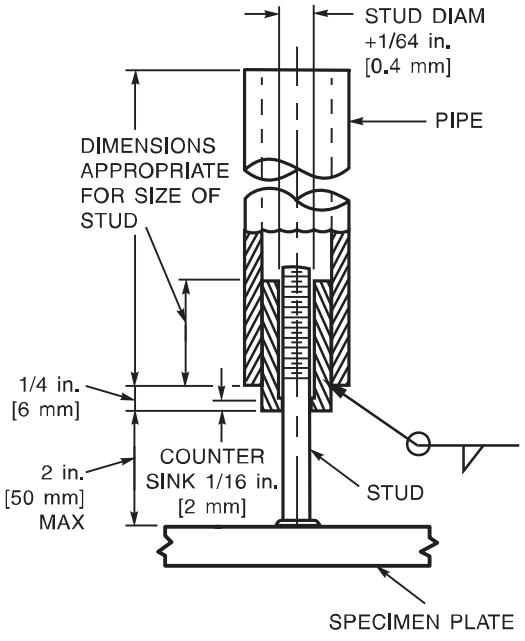


Figure G.2—Suggested Type of Device for Qualification Testing of Small Studs (see G7.2)