# 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 IX. Only studs with qualified stud bases shall be used. Qualification of stud bases in conformance with Annex IX 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 IX.

(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) with respect to each other and to edges of beam or girder flanges 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 IX), 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 IX, Figure IX-1 until failure occurs. Alternatively, studs may be bent 90° from their original axis. Type C studs, when bent 90 degrees, 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 E.

## 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 IX.

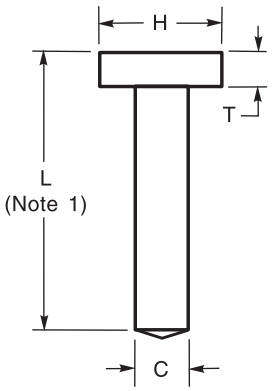
**Table 7.1**
**Mechanical Property Requirements for Studs (see 7.3.1)**

| | | Type A[1] | Type B[2] | Type C[3] |
|---|---|---|---|---|
| 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% | — |

Notes:
1. 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.
2. Type B studs shall be studs that are headed, bent, or of other configuration in 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.
3. 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 |




Note:
1. 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)**

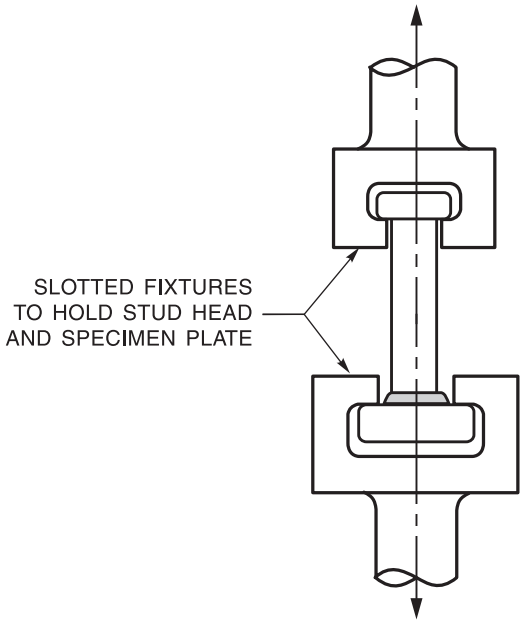
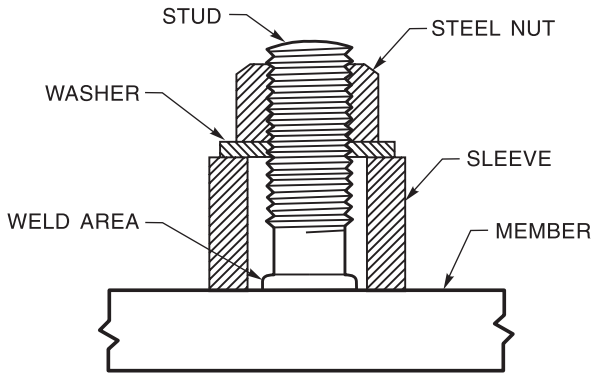



**Figure 7.2—Typical Tension Test Fixture (see 7.3.2)**




General 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[1]

| Nominal Diameter | | M.E.T.A.[2] | | Thread | | | Proof Testing Torque[3] | |
|---|---|---|---|---|---|---|---|---|
| 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 |

Notes:
1. Torque figures are based on Type A threaded studs with a minimum yield stress of 49 000 psi (340 MPa).
2. 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.
3. 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)**