

## INCIDENTAL CONSTRUCTION

### SECTION 502 SHEAR CONNECTORS

#### 502-1 Description.

Furnish and install welded shear connectors on steel beams and girders at locations shown in the Contract Documents. Field weld shear connectors located on the top flange only after the deck forms are in place. Installation of shear connectors in the fabrication plant is not permitted.

#### 502-2 General Requirements.

**502-2.1 Design:** Provide shear connector studs of a design suitable for end-welding to steel beams and girders, with automatically timed stud welding equipment. Provide the type, size or diameter, and length of stud as specified by the Contract Documents, and as approved by the Engineer. Meet the allowable tolerances on dimensions as specified in 502-7.

**502-2.2 Arc-Shield:** Furnish an arc-shield (ferrule), of heat-resistant ceramic or other suitable material, with each stud. Use material that is not detrimental to the welds, does not cause excessive slag, and has sufficient strength not to crumble or break due to thermal or structure shock before the weld is completed.

**502-2.3 Flux:** Furnish flux for welding with each stud, either attached to the end of the stud or combined with the arc-shield for automatic application in the welding operation.

**502-2.4 Coatings:** Do not paint or galvanize studs.

**502-2.5 Qualification:** Use only qualified studs, passing the tests prescribed in 502-6. Use the same arc-shield in production as used in the qualification tests.

**502-2.6 Data to be Submitted:** Before placing orders for studs, submit to the Engineer, for his approval, the following information on the studs to be purchased:

- (1) The name of the manufacturer.
- (2) A detailed description of the stud and arc-shield to be furnished.
- (3) A certification from the manufacturer that the stud is qualified as specified in

502-2.5.

- (4) A copy of the qualification test report as certified by the testing laboratory.

**502-2.7 Freedom from Defects:** After welding, ensure that the studs are free from any defect or substance that would interfere with their function as shear connectors.

#### 502-3 Materials.

**502-3.1 Metal:** For shear connector studs, meet the requirements of ASTM A108, cold-drawn bar, Grades 1015, 1017, or 1020, either semi-killed or fully-killed. If using flux-retaining caps, use caps of a low-carbon grade steel suitable for welding and meeting the requirements of ASTM A109.

**502-3.2 Mechanical Properties:** For tensile properties as determined by tests of bar stock after drawing, or of finished studs, meet the following requirements:

|                       |                      |
|-----------------------|----------------------|
| Tensile strength..... | 60,000 psi (minimum) |
| Yield strength* ..... | 50,000 psi (minimum) |

Elongation .....20% in 2 inches (minimum)  
Reduction of area ..... 50% (minimum)  
\*As determined by 0.2% offset method.

Determine tensile properties in accordance with ASTM A370. Perform tensile tests of finished studs on studs welded to test plates. If fracture occurs outside of the middle half of the gage length, repeat the test.

**502-3.3 Quality and Finish:** Provide finished studs of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, and other injurious defects. Produce a finish by cold drawing, cold rolling, or machining.

**502-3.4 Certification:** Ensure that the manufacturer certifies that the studs, as delivered, are in accordance with the materials requirements of this Subarticle. Furnish certified copies of in-plant quality control test reports to the Engineer upon request.

#### **502-4 Construction Requirements.**

**502-4.1 Equipment:** End weld stud shear connectors to steel beams or girders with automatically timed stud welding equipment connected to a suitable power source.

**502-4.2 Interlocking:** If two or more stud welding guns are to be operated from the same power source, interlock them so that only one gun at a time can operate and the operating gun finishes each weld before starting another weld.

**502-4.3 Condition of Studs:** At the time of welding, ensure that the studs are free from rust, rust pits, scale, oil, and other deleterious matter which would adversely affect the welding operation.

**502-4.4 Weather Limitations:** Do not weld when the base metal temperature is below 0°F, or when the surface is wet or exposed to rain or snow.

**502-4.5 Position of Welding Gun:** While operating, hold the welding gun in position without movement until the weld metal has solidified.

**502-4.6 Preparation of Areas:** Prepare the surface where studs are to be welded by wire-brushing, peening, prick-punching, grinding, or other approved methods to remove paint, scale, rust, oils, or other deleterious matter which would adversely affect the welding operation.

**502-4.7 Spacing:** Ensure that longitudinal and lateral spacing of studs with respect to each other and to edges of beam or girder flanges does not vary more than 1/2 inch from the dimensions shown in the Plans. However, the Engineer will allow a variation of 1 inch where required to avoid interference with other attachments on the beam or where welding a new stud to replace a defective stud. Provide a minimum distance of 1 inch from the edge of a stud to the edge of a beam, but where possible provide at least 1-1/2 inches.

**502-4.8 Testing:** After allowing them to cool, bend the first two studs welded on each beam or girder, 45 degrees by striking the stud with a hammer. If failure occurs in the weld of either stud, correct the procedure, and weld and test two successive studs successfully before welding any more studs to the beam or girder. Inform the Engineer of any changes in the welding procedure at any time during construction. When the temperature of the base metal is below 32°F, bend one stud in each 100 studs welded 45 degrees in addition to the first two bent as specified above.

**502-4.9 Repair of Welds:** The Contractor may repair studs, on which a full 360 degrees weld is not obtained, in accordance with the procedures of ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

**502-4.10 Reduction in Height:** If the reduction in the height of studs as they are welded becomes less than 1/16 inch, immediately stop welding and correct the cause. Do not resume welding until the cause has been corrected.

**502-4.11 Replacing Studs:** Before welding the replacement stud, remove the defective stud, grind the area smooth and flush or, in the case of a pullout of metal, fill the pocket with weld metal, using the shielded metal-arc process with low-hydrogen welding electrodes, and then grind flush. In compression areas of flanges, the Contractor may weld a new stud adjacent to the defective area in lieu of repair and replacement of the existing weld.

## **502-5 Inspection Requirements.**

**502-5.1 Bend Test:** If visual inspection reveals any stud which does not show a full 360 degrees weld, any stud which has been repaired by welding, or any stud in which the reduction in height due to welding is less than normal, strike such stud with a hammer and bend 15 degrees off the vertical. For studs showing less than a 360 degrees weld, bend the stud in the direction opposite to the lack of weld. Replace studs that crack in either the weld or the shank. The Engineer may select additional studs to be subjected to the bend test specified above. The Contractor may leave the tested studs that show no sign of failure in the bent position.

**502-5.2 Unsatisfactory Work:** If, during the progress of the shear connectors work, inspection and testing indicate that the shear connectors being obtained are not satisfactory, make such changes in welding procedure, welding equipment, and type of shear connector as necessary to secure satisfactory results, at no expense to the Department.

**502-5.3 Requalification:** If the Engineer requests, require the manufacturer of the studs to submit sample studs for requalification in accordance with the procedures of 502-6, at no expense to the Department.

## **502-6 Qualification Procedure.**

**502-6.1 Purpose:** The purpose of this procedure is to prescribe weldability tests which will qualify a shear connector stud for welding under shop or field conditions. The Contractor may have a university, independent laboratory, other testing authority, or agency perform the tests. Ensure that the agency performing the tests submits to the manufacturer of the stud a certified report giving procedures and results for all tests, including the information listed under 502-6.9.

**502-6.2 Duration of Qualification:** Once a type and size of stud with arc-shield has been qualified, the Engineer will consider the stud qualified until the manufacturer makes any change in the base of the stud, the flux, or the arc-shield, which affects the welding characteristics.

**502-6.3 Preparation of Specimens:** Prepare test specimens by welding representative studs to the center of square specimen plates, 1/2 to 3/4 inch thick, of structural steel, ASTM A36. The manufacturer may weld studs to a large plate and cut the specimen plates to a size suitable for test equipment used.

**502-6.4 Welding Procedure:** Weld studs with manufacturer recommended power source, welding gun, and control equipment. Measure welding voltage, current, and time by suitable instrumentation, and record these measurements for each specimen. Ensure that lift and plunge are at the manufacturer-recommended optimum setting.

**502-6.5 Number of Test Specimens:**

(1) Weld 30 test specimens consecutively, with optimum current and time. Make the optimum current and time the midpoint of the range normally recommended by the manufacturer for production welding.

(2) Weld 30 test specimens consecutively, with time held constant at optimum but with current 10% below optimum.

(3) Weld 30 test specimens consecutively, with time held constant at optimum but with current 10% above optimum.

#### **502-6.6 Qualification Tests:**

**502-6.6.1 Tensile Tests:** Subject 10 of the specimens welded in accordance with 502-6.5 (1), 10 in accordance with 502-6.5 (2), and 10 in accordance with 502-6.5 (3) to a tensile test. The Engineer will consider a stud qualified if all test specimens have a tensile strength above the minimum specified in 502-3.2.

**502-6.6.2 Bend Tests:** Place 20 of the specimens welded in accordance with 502-6.5 (1), 20 in accordance with 502-6.5 (2), and 20 in accordance with 502-6.5 (3) in a bend testing device, and bend alternately 30 degrees in opposite directions until failure occurs. The Engineer will consider a stud qualified if, on all test specimens, fracture occurs in the shank of the stud and not in the weld.

**502-6.7 Retest:** If weld failure occurs in any of the tensile or bend test groups, the Contractor may retest that group. If weld failure repeats, consider the stud as having failed to qualify.

**502-6.8 Qualification:** For a manufacturer's studs and arc-shields to be qualified, ensure that each group of 30 studs, by test or retest, meets the requirements prescribed in 502-6.6.

**502-6.9 Report of Tests:** Include the following in the laboratory report:

(a) Drawings which show shapes and dimensions with tolerances of studs, arc-shields, and flux.

(b) A complete description of materials used in the studs and arc-shields, including the quantity and analysis of the flux.

(c) A certification that the studs and arc-shields described in the report are qualified in accordance with 502-6.8.

#### **502-7 Dimensions and Tolerances.**

Meet the following dimensions and tolerances:

| C               | L*                                 | H                 | T                |
|-----------------|------------------------------------|-------------------|------------------|
| 3/4 - 1/64 inch | 4 +0.062 inches<br>4 -0.125 inches | 1 1/4 ± 1/64 inch | 3/8 inch minimum |
| 7/8 - 1/64 inch | 4 +0.062 inches<br>4 -0.125 inches | 1 3/8 ± 1/64 inch | 3/8 inch minimum |

\*4 inches length is standard.

The Contractor may obtain other lengths by special order.

Where:

C = Shaft diameter

L = Total stud length measured from top of head to base of shaft

H = Diameter of head

T = Thickness of head

**502-8 Method of Measurement.**

For the purpose of payment, shear connectors will be classified as Structural Steel. The quantity to be paid for will be determined in accordance with Section 460.

**502-9 Basis of Payment.**

Price and payment will be full compensation for all work specified in this Section, including furnishing and installing shear connectors.

Payment will be made in accordance with Section 460.