

SECTION 05 05 22

METAL WELDING

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. Welding Rod/Electrodes.
- B. Stud Shear Connectors.
- C. Shop Welding.
- D. Inspections and Tests by the Contractor.
- E. Inspections and Tests by the Engineer.

1.02 RELATED SECTIONS

- A. Welding of H-piles and pipe shells for piles is specified in Section 31 62 00, Driven Piles.
- B. Welding of reinforcing steel for concrete is specified in Section 03 20 00, Concrete Reinforcing.
- C. Welding and brazing of piping for plumbing and mechanical systems are specified under the applicable Sections.

1.03 MEASUREMENT AND PAYMENT

- A. Measurement: Welding and welds will not be measured separately for payment.
- B. Payment: Welding and welds, including inspections and tests to be performed by the Contractor, will be paid for as part of the indicated Contract unit prices for the associated steel and metal work.

1.04 REFERENCES

- A. American National Standards Institute (ANSI)/American Institute of Steel Construction (AISC):
 - 1. ANSI/AISC 341 Seismic Provisions for Structural Steel Buildings
 - 2. ANSI/AISC 360 Specifications for Structural Steel Buildings
- B. American Society for Nondestructive Testing (ASNT):
 - 1. SNT-TC-1A Recommended Practice

C. American Society for Testing and Materials (ASTM):

1. ASTM E94 Standard Guide for Radiographic Examination
2. ASTM E164 Standard Practice for Contact Ultrasonic Testing of Weldments
3. ASTM E165/E165M Standard Practice for Liquid Penetrant Examination for General Industry
4. ASTM E709 Standard Guide for Magnetic Particle Testing
5. ASTM E1032 Standard Test Method for Radiographic Examination of Weldments

D. American Welding Society (AWS):

1. AWS A2.4 Standard Symbols for Welding, Brazing and Nondestructive Examination
2. AWS A3.0M/A3.0 Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting and Thermal Spraying
3. AWS A5 Welding Rods, Electrodes, and Filler Metals Series
4. AWS B1.10M/B1.10 Guide for the Nondestructive Examination of Welds
5. AWS C5.4 Recommended Practices for Stud Welding
6. AWS D1.1/D1.1M Structural Welding Code – Steel
7. AWS D1.2/D1.2M Structural Welding Code – Aluminum
8. AWS D1.3/D1.3M Structural Welding Code – Sheet Steel
9. AWS D1.4/D1.4M Structural Welding Code – Reinforcing Steel
10. AWS D1.5M/D1.5 Bridge Welding Code
11. AWS D1.8/D1.8M Structural Welding Code – Seismic Supplement
12. AWS D9.1M/D9.1 Sheet Metal Welding Code
13. AWS D10.4 Recommended Practices for Welding Austenitic Chromium- Nickel Stainless Steel Piping and Tubing
14. AWS B2.1/B2.1M Specification for Welding Procedures and Performance Qualification
15. AWS QC1 Specification for AWS Certification of Welding Inspectors

1.05 REGULATORY REQUIREMENTS

- A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following code:
1. California Code of Regulations, Title 24, Part 2, California Building Code.
 2. California Occupational Safety and Health Administration (Cal/OSHA).

1.06 SUBMITTALS

- A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples, for submittal requirements and procedures. For Shop Drawings and other submittals, employ the standard welding symbols of AWS A2.4 and the standard welding terms of AWS A3.0M/A3.0.
- B. Welder Qualifications: Submit copies of qualification test records for each welder, welding operator, and tack welder to be employed in the work. Comply with requirements of AWS D1.1/D1.1M. For bridgework, comply with requirements of AWS D1.5M/D1.5. For seismic provisions, comply with requirement of AWS D1.8/D1.8M. For aluminum welders, comply with AWS D1.2/D1.2M. For pipe and tube, comply with requirements of AWS B2.1/B2.1M.
1. Submit welders identification marks (I.D.) for each welder along with qualifications.
- C. Welding Procedure Specifications (WPS): Prior to commencement of welding, submit the procedure specifications that will be used for welding. The WPS shall contain all data indicated in AWS D1.1/D1.1M Annex P, and any other information necessary to produce welded joints in compliance with this specification. For procedures other than those prequalified in accordance with AWS D1.1/D1.1M, D1.2/D1.2M, D1.5M/D1.5, and D1.8/D1.8M, submit a copy of procedure qualification test records in accordance with the qualification requirements of AWS D1.1/D1.1M, AWS D1.2/D1.2M, AWS D1.5M/D1.5, and AWS D1.8/D1.8M as applicable. WPS shall also include the mitigation of corrosion of welds, including heat treatment and chemical compatibility, as applicable.
- D. Welding Records and Data:
1. Submit all radiographs upon completion of fabrication.
 2. Submit certifications that magnetic particle and dye-penetrant inspections have been satisfactorily completed.
 3. Submit records of ultrasonic testing upon completion.
 4. If field welding is permitted, submit descriptive data for field welding equipment.

- E. Mill Certificates: Submit mill certificates and certified copy of reports for analyses and tests required by referenced ASTM and AWS specifications.

1.07 QUALITY CONTROL

- A. Qualification of Welders and Welding Procedures: Welders, welding operators, tack welders, and welding procedures shall be prequalified or qualified in accordance with the following AWS Welding Codes and Standards:
1. Structural Steel: AWS D1.1/D1.1M, Section 4, Qualification. Includes steel for miscellaneous metalwork, steel stairs, and railings.
 2. Stud Welding: AWS D1.1/D1.1M, Section 7.6, Stud Application Qualification Requirements.
 3. Structural Aluminum: AWS D1.2/D1.2M, Section 3, Qualification.
 4. Sheet Steel (Structural): AWS D1.3/D1.3M, Section 4, Qualification. Prequalification is not applicable to sheet steel.
 5. Concrete Reinforcing Steel: AWS D1.4/D1.4M, Section 6, Qualification. Coordinate with requirements specified in Section 03 20 00, Concrete Reinforcing.
 6. Steel for Bridges: AWS D1.5M/D1.5, Section 5, Qualification.
 7. Seismic Supplement: AWS D1.8/D1.8M, Section 5, Welder Qualification.
 8. Sheet Metal:
 - a. Welders: AWS D9.1M/D9.1, Section 6, Qualification of Arc Welders and Arc Welding Operators, and Section 11, Qualification of Braze Welders and Braze Welding Operators.
 - b. Welding Procedures: AWS D9.1M/D9.1, Section 5, Arc Welding Procedure Qualification, and Section 10, Braze Welding Procedure Qualification.
 9. Pipe and Tube: AWS B2.1/B2.1M
- B. Qualification of Welding Inspector: Welds to be inspected by the Contractor shall be inspected and certified by a Contractor-employed AWS Certified Welding Inspector (CWI), certified in accordance with AWS QC1.
- C. Qualification of Personnel Performing Nondestructive Testing: Personnel performing nondestructive testing, who are Contractor-employed, shall be qualified and certified in accordance with SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.
- D. Weldability of Steel: For structural steel requiring impact test qualification and for corrosion-resistant structural steel, the weldability of the steel and the procedures for

welding it shall be established by qualification in accordance with AWS D1.1/D1.1M, Section 4.

- E. Qualification of Stud-Connector Manufacturer: Stud shear connector manufacturer shall be qualified in accordance with AWS D1.1/D1.1M, Section 7.9, Manufacturers Stud Base Qualification Requirements.
- F. Stud Welding Standards: For stud welding, comply with applicable requirements of AWS C5.4 for steel and stainless steel, and AWS D1.2/D1.2M, Section 6, for aluminum.
- G. Moment-Resisting Frames: Welding of beam-to-column joint connections in moment-resisting frames shall conform with ANSI/AISC 341, ANSI/AISC 360, and AWS D1.8/D1.8M.
- H. Iron Contamination of Stainless Steel: Iron contamination of stainless steel will not be accepted. Welds shall be ground smooth and polished at the factory to blend in with the surrounding finish surfaces. Refer also to Section 05 70 00, Decorative Metal, for requirements.

PART 2 – PRODUCTS

2.01 WELDING ROD/ELECTRODES

- A. Electrodes for structural plate, shapes, pipe, tubes, and bars shall conform with AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform with AWS D1.1/D1.1M, AWS D1.5M/D1.5 and AWS D1.8/D1.8M, as applicable.
- B. Electrodes for sheet steel shall conform with AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform with AWS D1.3/D1.3M.
- C. Welding electrodes and welding rods for stainless steel shall conform with AWS A5.4 and AWS A5.9 as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metals shall be compatible with the Type 316 or Type 304 stainless steel, as applicable.
- D. Electrodes for aluminum shall conform with AWS A5.10 and AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform with AWS D1.2/D1.2M.

2.02 STUD SHEAR CONNECTORS

- A. Only products of manufacturers qualified in accordance with AWS D1.1/D1.1M, will be accepted for this work.

2.03 SHOP WELDING

- A. Perform shop welding as indicated in accordance with the California Building Code, AWS D1.1/D1.1M, AWS D1.2/D1.2M, AWS D1.3/D1.3M, AWS D1.5M/D1.5, AWS D1.8/D1.8M and AWS D9.1M/D9.1, as applicable to the work.
- B. Welders shall mark adjacent to completed welds their welder I.D., using metal stamp, metal engraving, keel, paint stick, or other appropriate marking material.
- C. Welding of stud shear connectors shall conform with AWS D1.1/D1.1M, Section 7, Stud Welding, AWS C5.4, Practices for stud welding and the stud manufacturer's instructions.
- D. Welding of stainless steel pipe and tube shall conform with applicable requirements of AWS D10.4.

2.04 INSPECTIONS AND TESTS BY THE CONTRACTOR

- A. Testing and Inspection: Testing and Inspection of welds shall proceed 24 hours after the completion of welding unless the Engineer has approved for a later time.
- B. Visual Inspection: All welds shall be visibly examined in accordance with AWS D1.1/D1.1M, AWS D1.5M/D1.5, and AWS D1.8/D1.8M, as applicable. Quality of welds and standards of acceptance shall be in accordance with AWS D1.1/D1.1M and AWS D1.5M/D1.5.
- C. Nondestructive Testing: Nondestructive testing shall conform with AWS B1.10M/B1.10.
- D. Radiographic Testing: Radiographic testing of welds shall conform with AWS D1.1/D1.1M, AWS D1.5M/D1.5 and ASTM E94, and ASTM E1032, as applicable. Complete joint penetration groove welds shall be tested as follows:
 - 1. 10 percent with thickness equal to or less than 3/4 inch.
 - 2. 50 percent with thickness greater than 3/4 inch and equal to or less than 1-1/2 inches.
 - 3. 100 percent for thickness greater than 1-1/2 inches.
- E. Ultrasonic Testing: Ultrasonic testing of welds shall conform with AWS D1.1/D1.1M, AWS D1.5M/D1.5 and ASTM E164, as applicable. Complete joint penetration groove welds not accessible for radiographic testing shall, with Engineer's approval, be subjected to ultrasonic testing. The extent shall be the same as specified for radiographic testing.

- F. Magnetic Particle Inspection: Magnetic particle inspection of welds shall conform with ASTM E709. Complete and partial joint penetration groove welds and fillet welds shall be inspected as follows:
 - 1. 20 percent of complete joint penetration groove welds of tee and corner joints.
 - 2. 10 percent of partial joint penetration groove welds and fillet welds.
- G. Liquid Penetrant Inspection: Liquid dye penetrant inspection of welds shall conform with ASTM E165/E165M. Liquid penetrant inspection shall be used for detecting discontinuities that are open to the surface.
- H. Test Results: Test result information shall be forwarded to the Engineer immediately after test results are available, stating the acceptance or rejection of fabricated components, so that repairs and reinspection or testing may be performed as soon as possible.
- I. Testing for Unacceptable Welds: If the herein specified testing or inspection indicated any failure weld or resulted in any unacceptable weld, the Contractor has to perform the same testing or inspection on a separate batch of welds other than the batches that were tested. This process shall be repeated until all welds in the same batch have passed the testing or inspection and are acceptable by the Engineer.
- J. Repairs: Unacceptable welds shall be repaired in accordance with AWS D1.1/D1.1M, AWS D1.5M/D1.5, and AWS D1.8/D1.8M, as applicable. Repaired or corrected welds shall be reinspected or retested as specified for the original weld.

2.05 INSPECTIONS AND TESTS BY THE ENGINEER

- A. All welds are subject to inspections and tests by the Engineer as specified herein. Welds to be inspected and tested by the Engineer will be selected at random.
- B. The Engineer will make test results available to the Contractor.

PART 3 – EXECUTION

3.01 FIELD WELDING

- A. Field welding, where indicated or permitted by the Engineer, shall be performed as herein specified for shop welding and comply with CAL/OSHA requirements. The Contractor shall identify a risk for fire damage and maintain a fire watch during the work as approved by the Engineer.

3.02 INSPECTIONS AND TESTS

- A. The Contractor shall perform inspections and tests of field welds as herein specified for shop welds.
- B. The Engineer reserves the right to perform inspections and tests of field welds as herein specified for shop welds.

3.03 CLEANING

- A. Welds shall be cleared in accordance with AWS D1.1/D1.1M.
- B. Welds of stainless steel shall be cleaned in accordance with Section 05 70 00, Decorative Metal, Article 3.02, Cleaning of Stainless Steel, and shall be protected from damage and corrosion at the factory, during shipping, and at the jobsite until acceptance of the work by the Engineer.
- C. All other cleaning requirements shall be in accordance with Section 01 74 14, Cleaning.

END OF SECTION 05 05 22