

APPENDIX B

GUIDELINES FOR WELDING QUALITY AND INSPECTION

Introduction

In order to provide the weld quality required for suitable testing, and to document the results of the actual welding, the following steps and standards are to be used for welding test samples that are to be representative of assumed practices.

It is intended that this protocol be used only for laboratory testing, not for actual shop and field applications. The requirements exceed current code requirements for shop and field use.

All welded joint design, welding operations, and inspection shall be in accordance with AWS D1.1-96 for statically loaded non-tubular structures. Wherever possible, prequalified materials, joints, welds and procedures should be used. See Section 3 for requirements for prequalification. Unless otherwise noted, all references to code sections made in this protocol are to provisions contained within AWS D1.1-96.

Inspector Qualification

General and visual welding inspection as described in this protocol shall be conducted by an inspector qualified under the provisions of Section 6.1.3. A Certified Welding Inspector or Senior Certified Welding Inspector is strongly preferred, and shall have been tested under the D1.1 code. CWI's with expired certificates are acceptable provided they have remained active in inspection since the time of expiration. A CWB qualified inspector shall be familiar with the provisions of D1.1. For a non-certified inspector under the terms of 6.1.3.1(3), the inspector should have a minimum ten years experience in active welding inspection, and provide documentation of employment stating such. The knowledge level of such inspector should be verified through personal interview, including technical questions and demonstration of inspection skills.

For nondestructive testing, such as penetrant (PT), magnetic particle (MT), ultrasonic (UT) and radiographic (RT) testing, the technician shall be qualified as a Level II technician, as defined by the ASNT Recommended Practice SNT-TC1A. Preferably, ANSI/ASNT CP-189-1995, Standard for the Qualification and Certification of Nondestructive Testing Personnel, shall be used to train and test personnel. The NDT personnel qualification process shall be managed by an ASNT Certified Level III for the NDT method, and shall have taken the test as administered by ASNT. Alternately, NDT personnel may be used who are certified as Level II in the NDT method through successful completion of the ASNT or AWS administered examinations for same.

Welding Procedure Specification

A written welding procedure specification (WPS) must be established and followed. For SMAW, FCAW and GMAW, the WPS must include the following information:

- a. process (SMAW, FCAW-S, FCAW-G, GMAW)
- b. steel specification or specifications to be welded
- c. thickness or thickness range to be welded
- d. sketch of the joint and weld to be made, including root opening, groove angle, root face, and groove radius, as applicable, with tolerances for the "as fit up condition"
- e. weld size to be made (fillet leg, groove pass layer thickness and width)
- f. position for welding
- g. electrode class and specification to be used
- h. diameter electrode to be used

- i. voltage of the welding machine
- j. current (amperage) setting or wire feed speed of the welding machine
- k. polarity setting of the welding machine (AC, DCEN, DCEP)
- l. if FCAW or GMAW, electrical stickout
- m. if gas-shielded, the type of gas and mix to be used
- n. if gas-shielded, the shielding gas flow rate
- o. travel speed to be used for welding
- p. technique to be used (stringer, weave beads)
- q. minimum and maximum preheat and interpass temperatures
- r. number and location of passes (range of passes for groove welds)
- s. any in-process nondestructive testing, beyond visual
- t. peening requirements, if any
- u. post-weld heat treatment requirements, if any
- v. type and material of backing bar, if used
- w. provisions for removal of backing bar, if needed, backgouging of the root, and a separate WPS for back welding
- x. tolerances for all dimensional values and the following procedure values: voltage, current or wire feed speed, travel speed, shielding gas flow rate

Should submerged arc welding (SAW) be proposed for any welding, approval of the Director of Topical Investigations must be secured. Welding parameters for SAW must be provided in addition to the items listed above.

For dimensional tolerances regarding joint design and fit-up, see Figure 3.3 for PJP groove welds and Figure 3.4 for CJP groove welds. For non-prequalified groove joint details, if used, see Figure 5.3.

For tolerances on welding procedure parameters, see Table 4.5. Welding procedure parameters must not exceed the manufacturer's limitations and recommendations for their particular product. These must be documented.

Should any of the WPS parameters exceed the limits of Table 3.7, a PQR (Procedure Qualification Record) is required. These limits include:

- maximum electrode diameter
- maximum current
- maximum root pass thickness
- maximum fill pass thickness
- maximum single pass fillet weld
- maximum single pass layer width

The WPS must be available to and used by the welder and welding inspector at the time of welding.

Qualified Welding Personnel

Any welding, including tack welds, must be done by qualified personnel. In order to be qualified, the welder must pass the hands-on qualification test(s) as prescribed in Section 4, Parts A and C. Welding personnel are qualified by:

- welding process
- welding position
- electrode classification
- thickness limitation
- type of weld to be made

The types of tests required and the qualification level achieved are tabulated in Table 4.9. The use of qualification tests of various types to qualify for other types of welds and other positions is tabulated in Table 4.8.

Written documentation of the test taken, including test results, is required. The welder may have taken the qualification test while working for another employer. If the welder testing was conducted over six (6) months prior to the welding to be performed, written documentation that the welder has welded using that process within the past six months is required. See 6.4 for further information.

Welding Equipment Inspection

Welding equipment, other than SMAW, shall be checked prior to welding for current and wire feed speed. This should be verified at least every three months if the same welding equipment is used for all welding. Written documentation of the tests and adjustments made on the equipment shall be available to the welding inspector. See D1.1 Sections 6.3.2 and 5.11, and AWS D1.5-95 or 96, section 4.26.

Welding Consumables Storage and Control

Welding consumables (electrodes, fluxes and gasses) shall be stored under controlled conditions as prescribed in Section 5.3.

SMAW low-hydrogen electrodes shall be purchased in hermetically sealed metal containers, received undamaged, or baked as prescribed in 5.3.2.4. All low-hydrogen SMAW electrodes shall be stored in rod ovens of at least 250°F, with labeling indicating rods currently available for use and rods which are not available for use as they are dried until a specific time has elapsed. The temperature of the rod oven shall be monitored at the beginning of every shift using a 250°F temperature indicating crayon. Atmospheric exposure time shall be limited to that stated in Table 5.1. Should SMAW electrodes be used that have permitted variable or extended exposure times, these times shall be documented in the manufacturer's literature.

FCAW and GMAW wire must be kept clean and dry, but storage or baking in rod ovens is not necessary.

If used, SAW fluxes shall be kept dry and stored in accordance with section 5.3.3. Recrushed slag shall not be used.

Base Metal Quality

The steel surfaces to be welded shall be visually inspected prior to welding. Surfaces shall be smooth, uniform, and free from fins, tears, cracks and other discontinuities which would adversely affect the quality of the weld. Surfaces to be welded and immediately adjacent to that area shall be free of loose or thick scale (scale that withstands vigorous wire brushing is acceptable), slag, rust, grease, coatings or other foreign materials. See Section 5.15.

Thermal cut surfaces to be welded should meet the surface roughness criteria of 5.15.4.3 and 4.

Joint Fit-Up

The fit-up of parts to be joined by fillet welds shall be checked for excessive gaps between the parts. Gaps up to and including 1/16" may be ignored. Gaps exceeding 1/16" up to 3/16" shall have their size increased accordingly. Gaps over 3/16" are permitted only in specific instances for thick steels and with root backing added. See 5.22.1.

The fit-up of parts to be joined by groove welding shall meet the requirements of the prequalified joint detail, if used, or the values of Figure 5.3, if not prequalified. For butt joints, parts shall be aligned in accordance with 5.22.3.

Preheat and Interpass Temperatures

Prior to commencing the welding of any joint, the joint shall be thoroughly preheated (if required) to the minimum temperature as provided in the WPS, not exceeding any maximum interpass temperature that may be stated. The minimum temperature of the steel shall be 32° F, or higher if required by Table 3.2. The temperature shall be measured at a distance 3" away from the joint, or a distance equal to the thickness of the thickest part being joined, if over 3" thick. Positive means shall be used to measure the temperature, such as temperature indicating crayons, surface temperature thermometers or infrared devices. Monitor the steel temperature between each pass to verify that it falls within the minimum and maximum values permitted. See Table 3.2 for minimum preheat and interpass temperatures for prequalified steels, and 5.6 for measurement requirements.

Wind Velocity in the Vicinity of Welding

When welding is being performed using gas shielded processes (FCAW-G, GMAW, GTAW, or EGW), the maximum wind speed in the vicinity of the weld is 5 miles per hour. See 5.12.1.

For other welding processes that do not use external gas shielding, wind speed shall be limited to approximately 20 mph. See 5.12.2.

Tack Welds

Tack welds shall be made following a written WPS, including provisions to provide preheat as required. The quality of the tack welds must meet the requirements for a finished weld, unless welded over using the SAW process. See 5.18.2

FCAW-S may not be used for tacking except for welds that will be completed using the FCAW-S process.

Monitor the condition of unwelded tack welds during welding to ensure that they do not crack under welding shrinkage stresses or distortion.

Post Weld Heat Treatment (PWHT)

If PWHT is required by the welding procedure, then the temperature at the joint shall be monitored and recorded every 10 minutes during heating and cooling and every 30 minutes during holding periods or as prescribed in the WPS. Measurements may be made using any positive

means, as described for preheat / interpass temperature inspection. See AWS D1.5-95 or 96, section 12.15 for guidance.

Inspection Responsibility

It is the responsibility of the welding contractor to ensure that all the above inspection provisions are met. In addition, independent outside inspection shall be provided to ensure the welding contractor's understanding of and compliance with these provisions. Outside inspection shall be provided during the welding of the first group of assemblies that will be used for physical testing. For later groups of assemblies, outside inspection should be provided as agreed upon by the contractor and SAC, dependent upon schedule, cost, welding requirements and the performance of the welding contractor during the welding of the first test assemblies.

Quality Criteria

Unless otherwise stated for specific test operations, the quality of all welds must meet the quality criteria set forth for statically loaded nontubular structures in D1.1-96. Refer to Table 6.1 for visual inspection acceptance criteria, also applicable to magnetic particle testing (MT) and penetrant testing (PT). Refer to 6.12.1 for radiographic testing (RT) acceptance criteria. Refer to 6.13.1 for ultrasonic testing (UT) acceptance criteria. Alternatively for UT, use Annex K, Table K-1, for statically loaded structures.

Also refer to section 5.24 for weld profiles, 5.29 for arc strikes and 5.30 for weld cleaning and surface slag.

Nondestructive Testing

Penetrant Testing (PT) - PT is not required except for weld access holes in heavy section tensile splices as defined in AWS section 5.17.2 or AISC section J1.5 and further described in AISC section J1.6 (LRFD).

Magnetic Particle Testing (MT) - For CJP groove welds in materials 5/16" or less in thickness at the joint, provide MT inspection of the entire length of weld. Document any discontinuities that exceed the visual acceptance criteria of Table 6.1, then repair and retest the repaired portion.

For fillet welds, perform MT of completed welds that fail to meet the surface profile convexity criteria of Figure 5.4. Only those portions of welds that exceed the convexity limits need be tested. Provide MT inspection of any repaired fillet welds.

Ultrasonic Testing (UT) - For CJP groove welds in materials over 5/16" thick, provide 100% UT for the full length of weld. Acceptance criteria is as provided in Table 6.2. Map all discontinuities that would be classified as Class A, B or C using Table 6.3 (Cyclically Loaded Nontubular Structures). Any other indications of Class D may be mapped at the discretion of the UT technician. Use the sample form as provided in Annex K, Figure K-15, for reporting purposes and mapping. Alternatively, use sample form D-11 provided in Annex D.

It is recommended that UT testing be performed on both the "A" and "B" faces for CJP groove welds to remain consistent with investigations on nondestructive testing underway in the SAC project. Results from both faces shall be documented.

As an alternative to the acceptance criteria of 6.13.1, use the acceptance criteria of Annex K, Table K-1, for statically loaded structures. Document the test results using the form provided in

Annex K, Figure K-15, for any indications classified as Level 1 or Level 2 for cyclically loaded structures. Documentation of cyclically loaded Level 3 discontinuities is at the discretion of the UT technician.

Radiographic Testing (RT) - Radiographic testing is not required. For butt joints, RT may be provided in addition to UT to assist in the documentation of discontinuities.

References

ANSI/AWS D1.1-96, Structural Welding Code - Steel, 1996, ANSI/AASHTO/AWS D1.5-95, Bridge Welding Code, 1995 (1996 edition may be used), American Welding Society, PO Box 351040, Miami, FL 33126, 800-443-9353

Standard for Qualification and Certification of Nondestructive Testing Personnel, 1995, American Society for Nondestructive Testing, PO box 28518, Columbus, OH 43228-0518, 800-222-2768