
PART VI
Appendix S
Welding Provisions

S.1 Scope

This Appendix provides additional details regarding welding and welding inspection, and is included on an interim basis pending adoption of such criteria by AWS or other accredited organization.

**S.2 STRUCTURAL DESIGN DRAWINGS AND SPECIFICATIONS,
SHOP DRAWINGS, AND ERECTION DRAWINGS**

S.2.1 Structural Design Drawings and Specifications

Structural design drawings and specifications shall include, as a minimum, the following information:

- (1) Locations where backup bars are required to be removed.
- (2) Locations where supplemental fillet welds are required when backing is permitted to remain.
- (3) Locations where fillet welds are used to reinforce groove welds or to improve connection geometry.
- (4) Locations where weld tabs are required to be removed.
- (5) Splice locations where tapered transitions are required.
- (6) The shape of weld access holes, if a special shape is required.
- (7) Joints or groups of joints in which a specific assembly order, welding sequence, welding technique or other special precautions are required.

S.2.2 Shop Drawings

Shop drawings shall include, as a minimum, the following information:

- (1) Access hole dimensions, surface profile and finish requirements.
- (2) Locations where backing bars are to be removed.
- (3) Locations where weld tabs are to be removed.
- (4) NDT to be performed by the fabricator, if any.

S.2.3 Erection Drawings

Erection drawings shall include, as a minimum, the following information:

- (1) Locations where backing bars to be removed.
- (2) Locations where supplemental fillets are required when backing is permitted to remain.
- (3) Locations where weld tabs are to be removed.
- (4) Those joints or groups of joints in which a specific assembly order, welding sequence, welding technique or other special precautions are required.

S.3 Personnel

S.3.1 QC Welding Inspectors

QC welding inspection personnel shall be associate welding inspectors (AWI) or higher, as defined in AWS B5.1 Standard for the Qualification of Welding Inspectors, or otherwise qualified under the provisions of AWS D1.1 Section 6.1.4 and to the satisfaction of the contractor's QC plan by the fabricator/erector.

S.3.2 QA Welding Inspectors

QA welding inspectors shall be welding inspectors (WI), or senior welding inspectors (SWI), as defined in AWS B5.1, except AWIs may be used under the direct supervision of WIs, on site and available when weld inspection is being conducted.

S.4 Nondestructive Testing Technicians

NDT technicians shall be qualified as follows:

- (1) In accordance with their employer's written practice which shall meet or exceed the criteria of the American Society for Nondestructive Testing, Inc. SNT TC-1A Recommended Practice for the Training and Testing of Nondestructive Personnel, or of ANSI/ASNT CP-189, Standard for the Qualification and Certification of Nondestructive Testing Personnel.
- (2) Ultrasonic testing for QA may be performed only by UT technicians certified as ASNT Level III through examination by the ASNT, or certified as Level II by their employer for flaw detection. If the engineer of record approves the use of flaw sizing techniques, UT technicians shall also be qualified and certified by their employer for flaw sizing.
- (3) Magnetic particle testing (MT) and dye penetrant testing (PT) for QA may be performed only by technicians certified as Level II by their employer, or certified as ASNT Level III through examination by the ASNT and certified by their employer.

S.5 Nondestructive Testing Procedures

S.5.1 Ultrasonic Testing

Ultrasonic testing shall be performed according to the procedures prescribed in AWS D1.1 (Section 6, Part F) following a written procedure containing the elements prescribed in paragraph K3 of Annex K, Section 6, Part F (AWS) procedures shall be qualified using weld mock-ups having 1.5 mm diameter side drilled holes similar to Annex K, Figure K-3 (AWS).

S.5.2 Magnetic Particle Testing

Magnetic particle testing shall be performed according to procedures prescribed in AWS D1.1, following a written procedure utilizing the Yoke Method that conforms to ASTM E709.

S.6 Additional Welding Provisions

S.6.1 Intermixed Filler Metals

When FCAW-S filler metals are used in combination with filler metals of other processes, including FCAW-G, a test specimen shall be prepared and mechanical testing shall be conducted to verify that the notch toughness of the combined materials in the intermixed region of the weld meets the notch toughness requirements of Section 10.20.7.3.1 and, if required, the notch toughness requirements for demand critical welds of Section 10.20.7.3.2.

S.6.2 Filler Metal Diffusible Hydrogen

Welding electrodes and electrode-flux combinations shall meet the requirements for H16 (16 mL maximum diffusible hydrogen per 100 grams deposited weld metal) as tested in accordance with AWS A4.3 Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding. (Exception: GMAW solid electrodes.) The manufacturer's typical certificate of conformance shall be considered adequate proof that the supplied electrode or electrode-flux combination meets this requirement. No testing of filler metal samples or of production welds shall be required.

S.6.3 Gas-Shielded Welding Processes

GMAW and FCAW-G shall not be performed in winds exceeding 5 km/hr. Windscreens or other shelters may be used to shield the welding operation from excessive wind.

S.6.4 Maximum Interpass Temperatures

Maximum interpass temperatures shall not exceed 290 °C, measured at a distance not exceeding 75 mm from the start of the weld pass. The maximum interpass temperature may be increased by qualification testing that includes weld metal and base metal CVN testing using AWS D1.1 Annex III. The steel used for the qualification testing shall be of the same type and grade as will be used in production.

The maximum heat input to be used in production shall be used in the qualification testing. The qualified maximum interpass temperature shall be the lowest interpass temperature used for any pass during qualification testing. Both weld metal and HAZ shall be tested. The weld metal shall meet all the mechanical properties required by Sec 10.20.7.3.1 or those for demand critical welds of Sec 10.20.7.3.2, as applicable. The heat affected zone CVN toughness shall meet a minimum requirement of 27 J at 21 °C with specimens taken at both 1 and 5 mm from the fusion line.

S.6.5 Weld Tabs

Where practicable, weld tabs shall extend beyond the edge of the joint a minimum of one inch or the thickness of the part, whichever is greater. Extensions need not exceed 50 mm.

Where used, weld tabs shall be removed to within 3 mm of the base metal surface, except at *continuity plates* where removal to within 6 mm of the plate edge is acceptable, and the end of the weld finished. Removal shall be by air carbon arc cutting (CAC-A), grinding, chipping, or thermal cutting. The process shall be controlled to minimize errant gouging. The edges where weld tabs have been removed shall be finished to a surface roughness of 13 μm or better. Grinding to a flush condition is not required. The contour of the weld end shall provide a smooth transition, free of notches and sharp corners. At T-joints, a minimum radius in the corner need not be provided. The weld end shall be free of gouges and notches. Weld defects not greater than 2 mm deep shall be faired to a slope not greater than 1:5. Other weld defects shall be excavated and repaired by welding in accordance with an applicable WPS.

S.6.6 Bottom Flange Welding Sequence

When using weld access holes to facilitate CJP groove welds of beam bottom flanges to column flanges or continuity plates, the groove weld shall be sequenced as follows:

- (1) As far as is practicable, starts and stops shall not be placed directly under the beam web.
- (2) Each layer shall be completed across the full width of the flange before beginning the next layer.
- (3) For each layer, the weld starts and stops shall be on the opposite side of the beam web, as compared to the previous layer.

S.7 Additional Welding Provisions for Demand Critical Welds Only

S.7.1 Welding Processes

SMAW, GMAW (except short circuit transfer), FCAW and SAW may be used to fabricate and erect members governed by this specification. Other processes may be used, provided that one or more of the following criteria is met:

- (a) The process is part of the prequalified connection details, as listed in Appendix N,
- (b) The process was used to perform a connection qualification test in accordance with Appendix Q, or
- (c) The process is approved by the engineer of record.

S.7.2 Filler Metal Packaging

Electrodes shall be provided in packaging that limits the ability of the electrode to absorb moisture. Electrode from packaging that has been punctured or torn shall be dried in accordance with the manufacturer's recommendations, or shall not be used for *demand critical welds*. Modification or lubrication of the electrode after manufacture is prohibited, except that drying is permitted as recommended by the manufacturer.

S.7.3 Exposure Limitations on FCAW Electrodes

After removal from protective packaging, the permissible atmospheric exposure time of FCAW electrodes shall be limited as follows:

- (1) Exposure shall not exceed the electrode manufacturer's guidelines.
- (2) In the absence of manufacturer's recommendations, the total accumulated exposure time for FCAW electrodes shall not exceed 72 hours. When the electrodes are not in use, they may be stored in protective packaging or a cabinet. Storage time shall not be included in the accumulated exposure time. Electrodes that have been exposed to the atmosphere for periods exceeding the above time limits shall be dried in accordance with the electrode manufacturer's recommendations, or shall not be used for demand critical welds. The electrode manufacturer's recommendations shall include time, temperature, and number of drying cycles permitted.

S.7.4 Tack Welds

Tack welds attaching backing bars and weld tabs shall be placed where they will be incorporated into a final weld.

PART VI**Appendix T****Weld Metal/Welding Procedure Specification Notch Toughness
Verification Test****T.1 Scope**

This Appendix provides a standard method for qualification testing of weld filler metals required to have specified notch toughness for service in joints designated as demand critical.

Testing of weld metal to be used in production shall be performed by filler metal manufacturer's production lot, as defined in AWS A5.01, Filler Metal Procurement Guidelines, as follows:

- (1) Class C3 for SMAW electrodes,
- (2) Class S2 for GMAW-S and SAW electrodes,
- (3) Class T4 for FCAW and GMAW-C, or
- (4) Class F2 for SAW fluxes.

Filler metals produced by manufacturers audited and approved by one or more of the following agencies shall be exempt from these production lot testing requirements, provided a minimum of 3 production lots of material, as defined above, are tested in accordance with the provisions of this appendix:

- (1) American Bureau of Shipping (ABS),
- (2) Lloyds Register of Shipping,
- (3) American Society of Mechanical Engineers (ASME),
- (4) ISO 9000,
- (5) US Department of Defense, or
- (6) A quality assurance program acceptable to the engineer of record.

Under this exemption from production lot testing, the filler metal manufacturer shall repeat the testing prescribed in this appendix at least every three years on a random production lot.

T.2 Test Conditions

Tests shall be conducted at the range of heat inputs for which the weld filler metal will be qualified under the welding procedure specification (WPS). It is recommended that tests be conducted at the low heat input level and high heat input level indicated in Table 6.T.1.

Table 6.T.1 WPS Toughness Verification Test Welding and Preheat Conditions

Cooling Rate	Heat Input	Preheat (°C)	Interpass (°C)
Low heat input test	31.2 kJ/mm	21 ± 14	93 ± 28
High heat input test	3.1 kJ/mm	149 ± 14	260 ± 28