

AN OVERVIEW ON GAS METAL ARC WELDING (GMAW) OF CARBON STEEL (CS)

Scope

This document provides information on welding and related operations of steel structures which are fabricated in accordance with the terms specified in latest editions of the following Codes:

- AWS D1.1/ D1.1M-Structural Welding Code, Steel

- AWS D1.3/ D1.3M-Structural Welding Code, Sheet Steel

Welding Procedure

The welding shall be done Semi-automatically using the Gas Metal Arc Welding (GMAW) process. (Note: Fully Automatic application can also be used.)

Note: In GMAW-Metal Cored Wire, if a fully automatic application is used, amperage can be increased by approximately 25%.

Semi-automatic welding: Welding with equipment that supplies continuous wire feed with or without means for mechanical travel. Manual manipulation by the welder of one or more of the variables of speed of travel, guidance, and direction of wire is involved during the welding operation.

Joints shall be made following the procedural stipulations indicated in Applicable Codes, and may consist of single or multiple passes as specified on WPS.

Base Metals

The base metals shall conform to any of the following groups:

-Steels in Groups I, II, III, IV of Table 5.3 of AWS D1.1 Code

-Steels in Table 6.9 of AWS D1.1 Code

-Steels in Groups I, II, III, IV of Table 1.2 of AWS D1.3 Code

Other materials and/ or specifications may be welded providing WPS are prepared, approved, and controlled by the Manufacturer, Fabricator, or Contractor, and shall be available to those authorized to use or examine them.

Base Metal Thicknesses

-AWS D1.1: Base metal thicknesses from 3 mm (1/8 in) to unlimited thickness

-AWS D1.3: Structural sheet/ strip steels, including cold formed members which are equal to or less than 5 mm (3/16 in) in nominal thickness

Essential Variables

Essential variables should be, as per Table 6.5 or Table 6.7 (Supplementary Essential Variable Changes for CVN Testing Applications) of the AWS D1.1 Code, or as per Table 6.2 of the AWS D1.3 Code.

Changes to any of the essential variables require requalification of WPS.

Highlights of Essential Variables:**AWS D1.1:****AWS D1.1 Table 6.5:** PQR Essential Variable Changes Requiring WPS Requalification

Following are general changes requiring a requalification for GMAW process based on Table 6.5 of AWS D1.1, however for full detail list of essential variables, Table 6.5 of AWS D1.1 applies:

- (a) a change in welding position not qualified by Table 6.1 [Plate]/ Table 10.8 [Pipe] of AWS D1.1
- (b) a change in diameter or thickness or both not qualified by Table 6.2 [Plate]/Table 10.9 [Pipe] of AWS D1.1
- (c) an increase in filler metal classification strength level
- (d) a change in base metal or combination of base metals not listed on the PQR or qualified by Table 6.8 of AWS D1.1
- (e) In vertical welding: For any pass from uphill to downhill or vice versa
- (f) a change in groove type (e.g. single-V to double-V), except qualification of any CJP groove weld qualifies for any groove detail conforming with requirements of 5.4.2 (PJP-Figures 5.2) or 5.4.1 (CJP-Figures 5.1), (10.9 or 10.10 [Tubular]) of AWS D1.1
- (g) a change in the type of groove to a square groove and vice versa
- (h) the omission, but not inclusion, of backing or backgouging

AWS D1.3:**AWS D1.3 Table 6.2:** PQR Essential Variable Changes Requiring WPS Requalification

Following are general changes requiring a requalification for GMAW process based on Table 6.2 of AWS D1.3, however for full detail list of essential variables, Table 6.2 of AWS D1.3 applies:

- (a) a change in welding position not qualified by Table 6.1 of AWS D1.3
- (b) an increase exceeding 30% in the thickness of coating of sheet steel
- (c) an increase in filler metal classification strength level
- (d) a change in the diameter of the electrode
- (e) a change in the type of coating or the addition, but not deletion, of coating material on base metal
- (f) In vertical welding: For any pass from uphill to downhill or vice versa
- (g) an increase in the root opening of a square groove weld
- (h) for square groove welds in butt joints, a change in welding from both sides to welding from one side, but not vice versa
- (i) the deletion, but not addition, of permanent or removable backing

Storage and Conditioning of Wires

Wires shall be dry and free from surface rust and foreign material.

Shielding Gas

The shielding gas shall be a welding grade having a dew point of -40 °C (-40 °F) or lower. The shielding gas/ wire combination shall be as shown on the WPS.

Shielding gas shall not be done in a draught or wind unless the weld is protected by a shelter. This shelter shall be of material and shape appropriate to reduce wind velocity in the vicinity of the weld to 8 km/hr. (5 mph).

Note for GMAW-Solid Wire:

Generally Ar+ 8-10% CO₂ is recommended for range of 3 mm (1/8 in) to 10 mm (3/8 in) on clean plates. Ar+ 14-17% CO₂ is recommended for range of above 12 mm (1/2 in) on clean or poor surface condition. Ar+ 5-13% CO₂+ 2-4% O₂ is recommended for range of 3 mm (1/8 in) to 20 mm (3/4 in) for moderately clean condition. Above ranges are only recommendation and not a limitation.

Note for GMAW-Metal Cored Wire:

Generally Ar+ 5-15% CO₂ or Ar+ 20-25% CO₂ are the most common shielding gases when using Metal Cored Wire. When using Ar+ 20-25% CO₂, voltages may be increased by approximately 1 to 1-1/2 volts compare to Ar+ 5-15% CO₂ gas.

Position(s) of Welding

The welding shall be done preferably in the flat position, but other positions such as horizontal, vertical and overhead are permissible as specified on WPS.

Electrical Characteristics

The welding current shall be direct current (reverse polarity) using a constant voltage type power supply. The range of parameters, as per wire manufacturer's instructions, will show on the WPS.

Minimum Preheat and Interpass Temperature

The minimum preheat before welding will comply with Table 5.8 of AWS D1.1 for Prequalified WPS or Notes of Table 6.9 of AWS D1.1 for Non-Prequalified WPS or as per Clause 7.4 and Annex A of AWS D1.3. Minimum preheat to be maintained or exceeded during welding.

If welding is interrupted for some time so that the temperature of the base metal falls below the minimum preheat temperature, and then arrangements will be made to preheat again prior to recommencing welding.

The weldment shall be allowed to cool to the ambient temperature without external quench media being supplied. In other words, do not cool using water or by immediate placement in frigid conditions which will cause a quick temperature change.

Heat Treatment and Stress Relieving

This will not be applicable to structures welded under this document, unless a specific WPS showing all the parameters and acceptance is obtained by an authorized person.

Types of WPS:

There are two types of WPS, Prequalified or non Prequalified. Prequalified WPS uses prequalified joint as specified in a governing code or standard that does not require validation of welding parameters through the performance of a procedure qualification test.

Prequalified joints and requirements for Prequalified WPS are outlined in the following parts of Codes:

-Clause 5 of AWS D1.1: In order for a WPS to be prequalified, conformance with all of the applicable requirements of Clause 5 shall be required.

-Clause 5 of AWS D1.3: In order for a WPS to be prequalified, conformance with all of the applicable requirements of Clause 5 shall be required.

Note: The use of a Prequalified joint shall not exempt the Engineer from using engineering judgment in determining the suitability of application of these joints to a welded assembly or connection.

Preparation of Base Material

The edges or surfaces of parts to be joined by welding shall be prepared by oxy-acetylene machine cutting. Where hand cutting is involved the edge will be ground to a smooth surface. All surfaces and edges shall be free from fins, tears, cracks or any other defects which would adversely affect the quality of the weld.

All loose or thick scale, rust, moisture, grease or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed.

Quality of Welds

Cracks or blow holes that appear on the surface of any pass shall be removed before depositing the next covering pass. The procedure and technique shall be such that undercutting of base metal or adjacent passes is minimized.

-AWS D1.1 7.23 Weld Profiles: All welds shall meet the visual acceptance criteria of Table 8.1 and Table 10.15, and shall be free from cracks, overlaps, and the unacceptable profile discontinuities exhibited in Figure 7.4, and Table 7.8, and Table 7.9, except as otherwise allowed in 7.23.1, 7.23.2, and 7.23.3

-AWS D1.3: Weld Acceptance Criteria shall meet the requirements of Section 8 of AWS D1.3

Weld Metal Cleaning

Slag remaining after a pass, shall be removed before applying the next covering pass. Prior to painting, all slag shall be removed and the parts shall be free of loose scale, oil and dirt.

Welding Technique

Refer to the WPS for the precise variables to be used in welding a particular thickness and joint configuration, position and parameters, i.e. stick-out, gas flow rate, travel speed, passes and layers, etc.

The selection of the torch angle depends on joint type, material thickness, edge preparation, in addition to the degree of skill and experience of the operator.

Generally, the forehand technique provides better visibility of the weld joint and a flatter weld puddle. The backhand technique yields better penetration. Torch angle is usually maintained with 10 to 20 degrees on either side of vertical.

The size of any single-pass weld or the size of the first pass of a multiple-pass weld size shall be such as to minimize the possibility of cracking.

Note1: For GMAW-Solid Wire:

End of contact tube recommended to be recessed in the cup nozzle between 3 mm (1/8 in) and 6 mm (1/4 in).

Note2: For GMAW-Metal Cored Wire:

End of contact tube recommended to be recessed in the cup nozzle at least 6 mm (1/4 in).

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged, or chipped to sound metal, unless otherwise specified on the applicable WPS.