AN OVERVIEW ON SUBMERGED ARC WELDING (SAW) 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 edition of the following Code:

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

Welding Procedure

The welding shall be done by the Submerged-Arc process (SAW) using either Automatic or Semi-automatic equipment with single or multiple arcs as specified on WPS.

Note: Direct current reverse polarity (DCRP) can be used for both Semi-automatic (hand held gun or mechanized welding gun) and Automatic (Machine) process; however AC current usually used for Automatic (Machine).

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.

Machine welding: Welding with equipment that performs the welding operation under the constant observation and control of a welding operator.

Automatic welding: Welding with equipment that performs the welding operation without adjustment of the controls by welding operator.

Commonly wire size that used for Semi-automatic is 1/16 inch for thickness from 14 gauge to 1/4 inch, and 5/64 inch for thickness from12 gauge and thicker for hand held gun (manual) to 3/32 inch wire size where gun is mechanically carried (mechanized); however common wire size for Automatic welding are 1/8, 5/32 and 3/16 inch.

Joints shall be made following the procedural stipulations indicated in Applicable Code, and may consist of single or multiple passes in accordance with the accepted WPS to which this document refers.

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

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.

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.

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

Highlights of Essential Variables:

AWS D1.1 Table 6.5: PQR Essential Variable Changes Requiring WPS Requalification

Following are general changes requiring a requalification for SAW 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] AWS D1.1

(b) a change in diameter or thickness or both not qualified by Table 6.2 [Plate]/Table 10.9 [Pipe]

(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) 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

(f) a change in the type of groove to a square groove and vice versa

(g) the omission, but not inclusion, of backing or backgouging

Base Metal Thicknesses

Base metal thicknesses shall be from 3 mm (1/8 in) to unlimited thickness, as per AWS D1.1

Flux Types

There are two common types of fluxes (Active and Neutral) that may be used in this procedure:

-Active flux is recommended for single pass fillet weld or only filling pass of butt joint and is limited to material thickness of maximum 25 mm (1in).

Note: Voltage must be more tightly controlled for multipass when using Active flux.

-Neutral flux can be used on multipass, unlimited thickness as it produces good impact properties; however, it is not usually the best choice for single pass as it has little or no resistance to cracking and/ or porosity.

Note: On square groove weld with only one pass from each side, both Active and Neutral flux can be used.

AWS classification numbers do not specify the results obtained when wire used with a particular flux. The classification of a wire should only be used as a guide to determine whether wire is suitable for a specific application. So AWS classification numbers do not indicate whether a flux and wire combination is Neutral or Active. For wire-flux combination to be considered neutral, it should have a Wall Neutrality Number of 40 or less.

Storage and Conditioning of Wires/ Fluxes

Wires shall be stored in suitable conditions that will keep them dry and free from surface rust and foreign material.

Flux used for submerged arc welding shall be dry and free from contamination of dirt, mill scale or other foreign material. All flux shall be purchased in packages capable of being stored under normal conditions for at least 6 months without such storage affecting its welding characteristics or weld metal properties. Flux from damaged packages that have been exposed to free moisture shall be discarded or shall be dried before use in shallow layers (2 in maximum) at minimum temperature of 500 ^{o}F for at least 1 hour or at time and temperature conditions as recommended by the manufacturer. Flux fused in welding shall not be reused.

Position(s) of Welding

The welding shall be done only in the flat position, except that for fillet weld both flat and horizontal position can be used as specified in WPS.

Electrical Characteristics

Amperage has main effect on parameter in SAW process. Most application use constant amperage, drag technique. Increasing voltage will increase flux consumption and also would increase pick-up of alloy from the active flux. Also by increasing electric stick-out (ESO) for a given wire feed speed, amperage should be decreased to melt wire as deposition rate would increase.

The current used shall be either direct current (DC) or alternating current (AC) as indicated on the WPS. DCRP is used for the most application because it produces smooth welds and has greater penetration. AC usually is used for Automatic (Machine) welding.

DCSP is also best option for fillet weld, commercial, single or multipass compare to DCRP that usually used for single pass, penetration fillet weld (strength only).

Note 1: Generally for AC, wire feed speed and deposition rate will increase 15-25% for given amperage compared with DCRP. Also voltage must be increased about 2 volts for AC compare with DCRP parameter setting.

Note 2: Normally for DCSP, voltage must be increased about 4 volts compare with DCRP; also ESO needs to be increased to get the maximum deposition rate. So in addition of 4 volts increase for switching from DCRP to DCSP, an increase of 2-4 volts for each inch increase on ESO is required.

Note 3: By switching from DCRP to DCSP, wire feed speed and deposition rate will increase 30-50% for given amperage compared with DCRP. Deposition rate may also vary about 10% depends on types of flux being used.

Note 4: Using of ESO extension will also increase deposition rate when using DCSP.

-While ESO on Semi-automatic welding typically is between 3/4 to1-1/8 inch, by using extension it can go up to 1-3/4 or 3 inches depend on wire size and gun being used.

-While ESO on Automatic welding typically is between 1 to 2 inch, by using extension it can go up to 5 inches depend on wire size and gun being used.

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. 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 part of code:

-Clause 5 of the AWS D1.1: 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.

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, flux, travel speed, passes and layers, etc.

Note: tolerances of +/-10% for Amp, +/-7% for Volts and +/-15% for travel speed should be kept when welding in SAW process.

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.

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.

To prevent cracking in fillet, recommended width at least 1.25 times more than depth of weld. Also avoid concave bead surface. For thickness above 25 mm (1 in), having gap of 1/32 to 1/16 inch allows the weld shrink during cooling.

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

Weld Metal Cleaning

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