Prepared for major welding processes {FCAW, SMAW (Stick), GMAW (MIG), SAW} for welding of Stainless Steels and Carbon Steels (members full access)

SUGGESTED SPEC. ON SHIELDED METAL ARC WELDING (SMAW) OF STAINLESS STEEL (SS)

Scope

This document provides information on welding and related operations of stainless steel which are fabricated in accordance with the terms specified in latest edition of the following Code:

- AWS D1.6/D1.6M-Structural Welding Code, Stainless Steel

Welding Procedure

The welding shall be done using the Shielded Metal Arc Welding (SMAW) process.

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

Fact on Stainless Steels

Stainless steels are commonly divided into the following general groups:

(1) Chromium Martensitic (4XX Series)

(2) Chromium Ferritic (4XX Series)

(3) Austenitic (include 2XX Series, Cr-Ni-Mn and 3XX Series Cr-Ni)

(4) Precipitation-hardening (which grades are assigned designations based on their Cr and Ni contents)

Austenitic stainless steels have excellent weldability; have better ductility and toughness than carbon steels or low alloy steels because of the Face-Centered cubic Crystal (FCC) structure.

Base Metals

The base metals used shall conform to ASTM austenitic stainless steel specifications as noted on the WPS.

Other grades of stainless steel may be welded provided accepted WPS are available.

Note: For the purpose of this document, Table 3.2 of Prequalified Austenitic Stainless Steels, base metal Groups A, B, C, D and E of the AWS D1.6 code can be used. However Alloy Designation like 304L, 304, 316L and 316 of group A or B are the most popular ones used in industry.

Base Metal Thicknesses

Base metal from 2.0 mm (1/16 in) or 16 gauge to unlimited thickness as per AWS D1.6 Code.

Filler Metals

Following are guides for choosing filler metal match for austenitic stainless steels:

-Joining of similar metal joints; use filler metal of matching composition (e.g. weld 304L material with 308L electrode).

-Dissimilar joining; use the lower alloyed of the two base metals (e.g. use 308 electrode to weld 304 to 316 materials).

-If both metals are low carbon (3XXL), then use low carbon (3XXL) filler metal as well.

-For low or high temperature, corrosive or any critical applications always confirm electrode choice with electrode manufacturer.

Note: For the purpose of this document, Table 3.3 of Prequalified Filler Metal Classifications, lists filler metal groups, based upon strength, which are prequalified for the corresponding prequalified Base Metal Group of Table 3.2 of AWS D1.6 Code. For welding of two different base metal groups in Table 3.2, use filler metal of Table 3.3, corresponding to the lower strength of the two base metal groups.

Some of the popular electrodes used in industry are EXXX-15, -16 and -17

EXXX-16, -17 produce less penetration compare with EXXX-15 and are recommended for flat groove position and flat/ horizontal fillet position. EXXX-15 produce globular mode and is good for all position, but EXXX-16, -17 produce spray mode of transfer (Note: All EXXX-15, -16, -17 electrodes can be used for all position).

Storage and Conditioning of Electrodes

All electrodes shall be delivered in sealed containers that do not show evidence of damage.

All electrodes shall be stored in warm and dry conditions and kept free from oil, grease and other deleterious matter once they have bee removed from their containers.

If reconditioning of electrodes is necessary, the electrode manufacturer's guidelines should be followed. Electrodes that have been wet shall be discarded.

Position(s) of Welding

The welding shall preferably be done in the flat position. The horizontal, vertical and overhead positions may be also used when specified on WPS.

Preheat and Interpass Temperature

Preheat does not normally apply to the welding of austenitic stainless steel, but if required, details will be shown on the specific WPS.

The minimum preheat shall be sufficient to remove moisture from the work. The maximum interpass temperature shall be 350 °F (175 °C) according to AWS D1.6 Code.

Electrical Characteristics

Welding equipment will be used having a dropping voltage characteristic. The welding current specified will be direct current electrode positive (DCRP) or alternating current (AC).

Some of the popular electrodes in industry are EXXX-15, -16 and -17

AC current is second choice for EXXX-16 and -17 electrodes as DCRP is preferred one. For AC, current has to be increased about 10% compare with DCRP.

Normally current for EXXX-15 electrode shall be 10% lower compare with EXXX-16 or -17 electrodes.

Note: AC current is not allowed for the purpose of prequalification.

Welding Technique

Refer to WPS for the precise SMAW variables to be used in welding a particular thickness, joint configuration, position and parameters.

The arc is initiated by quickly touching the tip of the electrode to the base metal and then quickly drawing the tip away. Once the arc is established it should be kept short to ensure sufficient shielding by the molten slag, but the electrode should not be allowed to touch the molten weld pool. Stringer beads are preferred over weaving to limit the heat input per pass. Weaving may be used for welds in the vertical position, limiting the weave width to 2.5 times the electrode diameter. A whipping technique should not be used.

All craters shall be filled at the end of each pass prior to breaking the arc. Weld metal shall be thoroughly cleaned of slag and other debris prior to depositing the next pass.

To reduce distortion, use stringer beads at a higher speed rather than wide beads at a slower speed, or use rigid fixtures to hold parts in alignment or use backing bars to makes cool faster.

Arc strikes outside of the area of welds should be avoided on any material.

Use short arc length to prevent loss of Cr-Ni pick-up.

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.

Larger size electrodes may be used for fill passes of the thicker material while smaller size electrodes usually applicable for root pass and/ or for thinner material.

Keep stainless steel materials clean and dry and keep them in separate place in warehouse.

Always use electrode size less than the thickness that you want to weld on.

Special ventilation and/or exhaust are required when welding high chromium alloys such as stainless steels.

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 Section 3 of AWS D1.6 Code.

Note 1: All prequalified WPS to be used shall be prepared, approved , and controlled by the manufacturer, fabricator, or Contractor as written prequalified WPS, and shall be available to those authorized to use or examine them.

Note 2: 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.

Limitation of Variables for Prequalified WPS:

Definition: Groove welds without steel backing, welded from one side, and groove welds welded from both sides, but without back gouging, are considered Partial Joint Penetration (PJP) groove welds for purposes of prequalification. In other hand Complete Joint Penetration (CJP) groove welds made without the use of backing shall have the root back gouged to sound metal before welding is started from the second side.

-**Prequalification covers weldments in thickness of 2 mm (1/16 in) or 16 gage and greater, designed for supporting mechanical loads under normal atmospheric corrosion conditions. It applies only to nominally austenitic stainless steel base metals and filler metals whose as-welded fusion zones normally contain a small amount of delta ferrite.**

-Base Metal Prequalification: Austenitic stainless steels whose filler metals normally produce a small amount of ferrite (as per Table 3.2 of AWS D1.6 for prequalified limits) shall be considered prequalified, provided they are welded with filler metals in accordance with Table 3.3 and the WPS used conform to all the applicable requirements of this code. **All other stainless steels or combinations, and WPS which are not prequalified, shall be qualified in conformance to this Code.**

-Steel for backing shall be of the same base metal group (Table 3.2 of AWS D1.6) as the base metal, unless otherwise approved.

-Roots of groove or fillet welds may be backed by copper or stainless steel backing to prevent melting through. Copper backing shall be removed and the root visually inspected.

-Neither the depth nor the maximum width in the cross-section of weld metal deposited in each weld pass shall exceed the width at the surface of the weld pass; see Figure 3.7 of AWS D1.6.

-For corner joints, the outside groove preparation may be in either or both members, provided the basic groove configuration is not changed and adequate edge distance is maintained.

Essential Variables

Essential variables should be, as per Table 4.1 of the AWS D1.6 Code. Changes to any of the essential variables require requalification of WPS.

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 moisture, grease or other foreign material that would prevent proper welding or produce objectionable fumes, shall be removed. Contact with lead, zinc, or lead or zinc compound shall be avoided due to the potential for hot cracking.

All surfaces to be welded shall be wire brushed prior to welding. In multi-pass welds the weld bead shall be wire brushed between passes. The brushes shall be of stainless steel and be kept exclusively for use on stainless steel and be kept clean and free of contaminants.

All other equipment such as grinding discs shall be kept exclusively for use on stainless steels.

Back gouging of welds shall produce a groove having a profile and a depth adequate to ensure fusion with the adjacent base metal and penetration into the root of the previously deposited weld metals.

Welds Quality

Cracks or blowholes 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.

Fillet and groove welds shall meet the desirable or acceptable weld profiles specified in Clause 5.11 of AWS D1.6.

All welds shall be free of cracks and overlap.

The reinforcement in groove welds shall not exceed 3 mm (1/8") and shall have a gradual transition to the plane of the base metal surface. Undercut shall be limited to that described in Clauses 6.28 and 6.29 of AWS D1.6.

In general, the weld quality will be such as to meet the requirements of Clause 6.28 (for statically loaded structures) and/ or 6.29 (for cyclically loaded structure) of AWS D1.6.

Weld Metal Cleaning

Slag or flux remaining after a pass, shall be removed before applying the next covering pass. After the final pass all slag and weld spatter shall be removed. Arc strikes shall be removed by grinding or other suitable means (by using only stainless steel chipping tool, brush). Cracks or blemishes caused by arc strike shall be ground to a smooth contour and examined visually to assure complete removal.