**Ref. Sample WPS: SMAW-SS**

COMPANY NAME: **WeldCanada.com**

COMPANY ADDRESS: **info@WeldCanada.com**

# WELDING PROCEDURE SPECIFICATION (WPS) FOR SHIELDED METAL ARC WELDING (SMAW) OF STAINLESS STEEL

## About WPS:

Welding Procedure Specification (WPS) is a general document that outlines shop and field welding practice and limitations for a welding process. Welding parameters and ranges are specified and used to prepare associated WPDS.

## About WPDS:

Welding Procedure Data Sheet (WPDS) is a document, used in conjunction with a WPS, detailing the welding parameters and ranges for welding a specific joint, over a range of thicknesses and weld sizes, as illustrated on the data sheet.

## Scope

This WPS covers welding and related operations of stainless steel which are fabricated in accordance with the terms specified in the latest editions of the following Standards:

**- CSA W47.1-Certification of Companies for Fusion Welding of Steel**

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

Note: CSA W59-Welded Steel Construction (Metal Arc Welding) may be referenced when joining stainless steel to carbon steel.

This WPS will be presented to the Canadian Welding Bureau (CWB) along with the related WPDS for approval.

## Welding Procedure

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

Joints shall be made by single or multiple pass welding, from one or both sides as per accepted WPDS that referring to this specification.

## 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 WPDS, welded to each other or to carbon steels conforming to the specifications of steel groups 1, 2 and 3 of table 11-1/ 12-1 of CSA W59 Standard.

Other grades of stainless steel and carbon steel may be welded provided accepted WPDS are available.

Note: For the purpose of this WPS, 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 may be welded under this specification provided that WPDS has been supplied and accepted by CWB. Thicknesses less than 2.0 mm (1/16 in) may be welded providing data sheets have been accepted by the CWB.

**Filler Metals**

The filler metal shall be certified by the Canadian Welding Bureau as conforming to CSA Standard W48 latest edition.

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 WPS, 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 the 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 with accepted WPDS referring to those positions.

**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 WPDS.

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

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 WPDS:**

There are two types of WPDS, Prequalified or non Prequalified. Prequalified WPDS 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 WPDS are outlined in Section 3 of AWS D1.6.

**Note 1:** All prequalified WPDS to be used shall be prepared, approved, and controlled by the manufacturer, fabricator or Contractor as written prequalified WPDS, 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 WPDS:**

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 WPDS used conform to all the applicable requirements of this code. **All other stainless steels or combinations, and WPDS 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 Standard.

-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 WPDS.

**Note:** When required by the CSA W47.1 Standard or when there is a conflict that make the CSA W47.1 take precedence over the AWS D1.6 code (for example, when welding stainless steel of AWS D1.6 code to carbon steel of the CSA W59 Standard), essential variables of the CSA W47.1 Clause 11, may apply (this should be decided by an authorized company's engineer with approval of the CWB):

**CSA W47.1: Clause 11.4.2:** Essential variables for soundness and mechanical testing shall be as specified in Tables 11 and Clause 11.4.3

**CSA W47.1: Clause 11.4.3:** The PQR mechanical test essential variable changes requiring a requalification for the SMAW process shall be as follows:

(a) a change in the base metal steel group (number) as defined in Table 17;

(b) a change in welding process;

(c) an increase in filler metal classification strength level;

(d) a change of thickness outside the range allowed by Table 13

**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 D 1.6.

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 D 1.6.

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 D 1.6.

**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.

**Engineer or Supervisor Signature** **CWB Acceptance**