WELDING PROCEDURE SPECIFICATION

Shielded Metal Arc Welding-SMAW

WPS Number: WPS-SMAW-CS

Revision: 0

Company Name & Address

ABC WELDING & FABRICATING

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CWB Approval	Welding Engineer / Welding Supervisor Approval
	Approved for Pages (1-12)

Table of Contents

1.0 SCOPE

1.1 This Welding Procedure Specification (WPS) covers welding and related operations of steel structures fabricated in accordance with the terms outlined in the following reference standards:

CSA W47.1-09
CSA W59-13

Provisions of following AWS standards may also be applied provided relevant Welding Procedure Data Sheets have been supplied and approved by Canadian Welding Bureau. However, when the provisions of AWS Standard and CSA Standard conflict, CSA W47.1-09 Standard takes precedence.

AWS D1.3- (latest edition)
AWS D1.1-2015- (latest edition)

A Change in any of the essential variables described in respective reference standard or detailed on Welding Procedure Data Sheets shall require a new Welding Procedure Specification and / or Welding Procedure Data Sheet.

1.2 The attached Welding Procedure Data Sheets (**WPDS)** are an essential part of this **WPS**.

2.0 WELDING PROCEDURE

2.1 The Welding shall be done manually using Shielded Metal Arc Welding, SMAW process.

2.2 Joints shall be made following the procedural stipulations indicated in CSA Standard W59-13 and may consist of single and multi passes in accordance with the approved Welding Procedure Data Sheet to which this specification refers.

2.3 Joints may also be made following procedural stipulations indicated in AWS Standard AWS D1.1 and AWS D1.3 and may consist of single and multi passes provided Welding Procedure Data Sheets (WPDS) have been supplied and approved by Canadian Welding Bureau (CWB).

3.0 BASE METAL

3.1 The Base metal shall conform to the Specification of Steel Groups 1, 2, 3 of Table 11.1 and Table 12.1 of CSA Standard W59-13. Other groups may be welded providing Welding Procedure Datasheets (WPDS) are accepted by CWB.

Base metal to be welded shall be as per CWB approved Welding Procedure Datasheet.

3.2 Base metal thickness from 3mm (1/8") to UNLIMITED THICKNESS may be welded under this specification provided respective Welding Procedure Data Sheets have been supplied and approved by CWB.

4.0 GENERAL

4.1 The welder or welding operator, the work, and the welding consumables shall be adequately protected against the direct effect of wind, rain, and snow, and all necessary means shall be provided to enable the welder or welding operator to work in reasonable comfort.

4.2 Welding shall not be done when the ambient temperature is lower than –18°C (0°F) except with the express consent of the Contractor's Engineer.

4.3 For pre-qualified joints, maximum electrode size, thickness of layers and maximum single pass fillet shall be as per Table 10.1 of W59-13.

5.0 FILLER METAL

5.1 Electrodes certified by CWB to the requirements of CSA Standard W48 shall be used.

5.2 ***SMAW classifications with no diffusible hydrogen designator or a diffusible hydrogen designator of H16 or less may be used for welding of all steels in Column 2 of Table 5.3 of W59-13. SMAW classifications with a diffusible hydrogen designator of H8 or less shall be used for welding of all steels in Columns 3 and 4 of Table 5.3. SMAW classifications with a diffusible hydrogen designator of H4 shall be used for welding all steels in Column 5 of Table 5.3. See also Clause 5.5.1.6 of W59-***

13 for steels in Column 5 of Table 5.3. If notch toughness is a consideration for steels in that column, then electrodes having appropriate impact properties shall be selected.

5.3 Filler metal shall be compatible with the base metal, as specified in Table 11.1 and 12.2 of CSA Standard W59-13. Filler metal for exposed, bare, unpainted applications of CSA G40.21 350A, 350AT, 400A, 400AT and ASTM A242 and A588 shall meet requirements of clause 5.2.1.5, 5.2.1.6 and table 5.1 of CSA standard W59-13.

6.0 STORAGE AND CONDITIONING OF ELECTRODES

6.1 Low-Hydrogen Electrodes

All low-hydrogen electrodes shall be delivered in sealed containers or shall be reconditioned in accordance with (a), (b) or (c) below. If sealed containers show evidence of damage, electrodes shall be reconditioned in accordance with (a), (b), or (c) below. ***Electrodes that have been wet shall be discarded.***

(a) Carbon steel electrodes conforming to CSA Standard W48 shall be baked for at least 2 hours at a temperature between 230°C (450°F) and 260°C (500°F) before being used.

(b) Low-alloy steel electrodes conforming to CSA Standard W48 shall be baked for at least 1 hour at a temperature between 370°C (700°F) and 430°C (800°F).

(c) Alternative baking temperatures for low-hydrogen electrodes may be used if such procedures have been developed and are recommended by the manufacturer; the use of these alternative procedures shall be approved by the Engineer.

6.2 Immediately after opening sealed containers or removal from baking ovens for reconditioning in accordance with above clause 6.1, electrodes shall be stored in ovens held at a temperature of at least 120°C (250°F).

6.3 Except as noted in clause 6.4 below, low-hydrogen electrodes of the E49 classification that are not used within 4 hours after removal from ovens shall be reconditioned in accordance with clause 6.1 above.

6.4 When approved by the Contractor's Engineer, auxiliary electrode containers or dispensers may be used to extend permissible exposure times in accordance with the following:

(a) The Contractor's Engineer shall be satisfied that such electrode containers or dispensers have been demonstrated to provide adequate atmospheric sealing protection for the contained electrodes at a relative humidity of 90% at 30°C (86°F) for the total storage time proposed for acceptance.

(b) The electrodes so contained shall not produce diffusible hydrogen levels in weld metal in excess of the requirements of CSA Standard W48.

Low-hydrogen electrodes of the E49XX (E70XX) classification that are not used within a maximum of 10 hour total exposure time after being removed from ovens and stored in approved electrode containers or dispensers shall be reconditioned in accordance with clause 6.1above.

(c) The use of alternative exposure times, if recommended by the electrode manufacturer, may be used if approved by the Contractor's Engineer.

(d) Low-hydrogen electrodes with strength levels higher than the E49 classification that are not used within a time period equal to 50% of the maximum permissible exposure time* for E49 electrodes, as specified in above Clause 6.3 or 6.4, shall be rebaked between 370 °C (700°F) and 430 °C (800°F) for 1 h before they are used.

*Shorter periods may be considered under conditions of high atmospheric humidity and temperature.

Note: When welding quenched and tempered steel, more stringent baking and exposure time control requirements may be necessary.

6.5 Low-hydrogen electrodes shall be rebaked no more than once.

6.6 Non-Low-Hydrogen Electrodes

All non-low-hydrogen electrodes shall be stored in warm and dry conditions and kept free from oil, grease, and other deleterious matter once they have been removed from their containers and packages.

6.7 Longer electrode exposure times than those recommended in clause 6.3 and 6.4(d) are permitted if recommended by the electrode manufacturer.

7.0 PREPARATION OF BASE METAL

Surfaces and edges to be welded shall be smooth, uniform, and free from fins, cracks, and other defects that would adversely affect the quality or strength of the weld. Surfaces to be welded shall also be free, within 50 mm (2 in) of any weld locations, from loose or thick scale (except for tightly adhering small islands of scale), slag, loose rust, paint, grease, moisture, and other foreign material that will prevent welding to the acceptance criteria of this Standard.

Machining, air carbon arc or oxy-fuel gas gouging, chipping, or grinding may be used for joint preparation, for back-gouging, or for the removal of defective work or material, except that oxygen-fuel gouging shall not be used on quenched and tempered steels.

8.0 PRE HEAT, INTERPASS TEMPERATURE, AND HEAT INPUT CONTROL

The preheat and interpass temperature shall be sufficient to prevent cracking. Preheat and interpass temperatures shall be as shown in Table 5.3 of W59-13 (shown below), except when the provisions of Clause 5.7.2 of W59-13 are used.

Preheat and interpass temperatures above the minimum shown in Table 5.3 may be used
(a) For highly restrained welds;
(b) For certain combinations of steel thickness and weld energy input levels when the steel composition contains elements such as carbon, manganese, chromium, and nickel that are at or near the maximum values permitted by the steel specification;
(c) For high-strength weld metal; and
(d) For joints where transfer of tensile stress occurs in the through-thickness direction of the material.

Note: Experience has shown that the minimum temperatures specified in Table 5.3 are adequate to prevent cracking in most cases. However, higher preheat temperatures may be used in situations involving higher restraint, higher hydrogen, lower welding heat input, or steel composition at the top end of the specification. Alternatively, lower preheat temperature may be adequate to prevent cracks, depending on

restraint, hydrogen level, and actual steel composition or higher welding heat input. Alternatively, minimum preheat and interpass temperatures may be established on the basis of steel composition, using recognized methods of prediction or guidelines. Details of some of the selected methods are given in Annex P. These methods are based on laboratory cracking tests and may predict preheat levels higher than the minimum levels shown in Table 5.3. Annex P may be of value in identifying situations where the risk of cracking is increased due to composition, restraint,hydrogen level, or lower welding heat input where higher preheat may be warranted. Alternatively, Annex P may assist in defining conditions under which hydrogen cracking is unlikely and where the minimum requirements of Table 5.3 of W59-13 may be safely relaxed.

Preheat and Interpass Temperatures for Quench & Tempered Steels:

For welding of quenched and tempered steels, the steel manufacturer's recommendations stating the maximum permissible heat input, preheat and interpass temperature necessary to achieve proper welding shall be taken into account. Such considerations must include the additional heat input produced in simultaneous welding on the two sides of a common member.
For quenched and tempered steel, the maximum preheat and interpass temperature shall not exceed 200°C (400°F) for thicknesses up to 40 mm (1-1/2 in) inclusive and 230°C (450°F) for greater thicknesses.

Electrodes of any classification used for welding quenched and tempered steels shall have been shown to have given a diffusible hydrogen content not to exceed H4 (4 mL of diffusible hydrogen/100 grams of deposited weld metal) when measured in accordance with AWS A4.3 or ISO 3690; or alternatively, the hydrogen control method in Annex P may be utilized to determine permissible hydrogen levels depending on restraint, steel composition, and welding heat input.

Table 5.3				
Minimum preheat and interpass temperatures[1,2,3]				
Thickness of thickest part at point of welding, mm (in)	Welding Process			
	SMAW, FCAW, MCAW, and SAW, using consumables with diffusible hydrogen designators of ≤ H 16, or without a diffusible hydrogen designator or any non-low hydrogen electrode	SMAW, FCAW, MCAW, and SAW, using consumables with diffusible hydrogen designators of ≤ H8 GMAW, GTAW		SMAW, FCAW, MCAW, and SAW, using consumables with diffusible hydrogen designators of ≤ H4 GMAW, GTAW
1	2	3	4	5
	API 5L X42	**API 5L X52**	**CSA G40.21** 400W (60W), 400WT (60WT) 480W (70W), 480WT (70WT), 480A (70A), 480AT (70AT)	**CSA G40.21** 700Q (100Q), 700QT(100QT)
	CSA G40.21 260W (38W),260WT (38WT),300W (44W),300WT, (44WT)	**CSA G40.21** 260W (38W),260WT (38WT),300W (44W),300WT (44WT)		
		350W (50W), 350WT (50WT), 350A (50A), 350AT (50AT), 380W (55W),380WT (55WT), 400A (60A), 400AT (60AT)		
	ASTM A36, A53 Grade B, A106 Grade B A131 Grades A, B, CS, D, DS, and E , A139 Grade B,A381 Grade Y35, A500 Grades A, B, and C, A501	**ASTM** A36, A53 Grade B, A106 Grade B, A131 Grades A, B, CS, D, DS, and E, A131 Grades AH 32 and 36, A131 Grades DH 32 and 36, A131 Grades EH 32 and 36 A139 Grade B, A242†, A381 Grade Y35,A441 A500 Grade A, B, C, A501, A515 Grade 55	**ASTM** A515 Grades 60 and 65	**ASTM** A514 A517
	ASTM A516 Grades 55 and 60 A524 Grades I and II, A573 Grade 58, A607* Grades 45, 50, A709 Grade 36, A1008 SS Grade 30, 33 Type 1, 40 Type 1, A1011 SS Grade 30, 33, 36 Type 1, 40, 45, 50, 55	**ASTM** A516 Grades 55, 60, 65, and 70, A524 Grades I and II A529 Grades 50 and 55, A537 Class 1 and 2 A572 Grade 42, 50, and 55, A573 Grade 65, A588, A595 Grades A, B, and C A606, A607 all grades, A618 Grades Ib, II, and III, A633 Grades A, B, C, and D, A709 Grade 36, 50, 50S, 50W, and HPS 50W, A710 Grade A Class 2 > 50 mm, A710 Grade A Class 3 > 50 mm A808 [t < 65 mm], A847, A913 Grade 50 A992 A1008 HSLAS Grade 45 Class 1 and 2 Grade 50 Class 1 and 2, Grade 55 Class 1 and 2, A1008 SS Grades 30, 33 Type 1, 40 Type 1, A1008 HSLAS-F Grade 50	**ASTM** A572 Grade 60, 65 A633 Grade E A709 Grade HPS70W A710 Grade A Class 2 ≤ 50 mm A852 A913 Grade 60, 65	

(Continued)

Table 5.3				
Minimum preheat and interpass temperatures[1,2,3]				
Thickness of thickest part at point of welding, mm (in)	Welding Process			
	SMAW, FCAW, MCAW, and SAW, using consumables with diffusible hydrogen designators of ≤ H 16, or without a diffusible hydrogen designator or any non-low hydrogen electrode	SMAW, FCAW, MCAW, and SAW, using consumables with diffusible hydrogen designators of ≤ H8 GMAW, GTAW		SMAW, FCAW, MCAW, and SAW, using consumables with diffusible hydrogen designators of ≤ H4 GMAW, GTAW
1	2	3	4	5
		ASTM A1011 HSLAS Grade 45 Class 1 and 2 Grade 50 Class 1 and 2, Grade 55 Class 1 and 2 A1011 SS Grades 30, 33, 36 Type 1, 40, 45, 50 , 55, A1011 HSLAS-F Grade 50 A1018 HSLAS, Grade 45 Class 1 and 2, Grade 50 Class 1 and 2 Grade 55 Class 1 and 2 A1018 HSLAS-F Grade 50, A1018 SS Grades 30, 33, 36 and 40	**ASTM** A1018 HSLAS Grade 60 Class 2 Grade 70 Class 2 A1018 HSLAS-F Grade 60 Class 2 Grade 70 Class 2	
Over 20 mm (3/4") to 40 mm (1.5")	65 °C (150°F)	10 °C (50°F)	65 °C (150°F)	50 °C (125°F)
Over 40 mm (1.5") to 60 mm (2.5")	110 °C (225°F)	65 °C (150°F)	110 °C (225°F)	80 °C (175°F)
Over 60 (2.5")	150 °C (300°F)	110 °C (225°F)	150 °C (300°F)	110 °C (225°F)

**Only for thicknesses up to* 8 mm (5/16 in).
†Grades suitable for welding. See Clause 3.2.2.
‡When the base metal temperature is below 0 °C (32°F)*, the base metal shall be preheated to at least* 10 °C (50°F) *and this temperature maintained during welding.*

Notes:

(1) *Welding shall not be done when the ambient temperature is lower than* –18 °C (0°F)*, except with the express consent of the Contractor's Engineer.*

(2) *When the base metal is below the temperature listed for the welding process being used and for the thickness of the material being welded, it shall be preheated (except as otherwise provided) in such a manner that the surfaces of the parts on which weld metal is being deposited are at or above the specified minimum temperature for a distance equal to the thickness of the part being welded, but not less than* 75 mm (3 in)*, both laterally and in advance of the welding.*
Preheat and interpass temperatures shall be sufficient to prevent crack formation. For quenched and tempered steel, the maximum preheat and interpass temperature shall not exceed 200 °C (400°F) *for thicknesses up to* 40 mm (1-1/2 in) *inclusive and* 230 °C (450°F) *for greater thicknesses. Heat input, when welding quenched and tempered steel, shall not exceed the steel producer's recommendations.*

(3) *For matching electrode classification, see Tables 11.1 and 12.1.*

9.0 STRESS RELIEF HEAT TREATMENT

Where required by the contract drawings or specifications, welded assemblies shall be stress relieved by heat treatment. Specific welding procedure data sheets indicating all parameters for stress relief heat treatment shall be submitted to CWB for approval.

Post-weld heat treatment is not generally recommended for welded assemblies of quenched and tempered steels, such as ASTM A514, A517, A709 Grades 100 and 100W, and CSA G40.21, Grades 700Q and 700QT, and it should not be applied to copper bearing age-hardening steels such as ASTM A710. The vanadium content of weld metal in assemblies subject to PWHT should not exceed 0.05%.

Requirements of Clause 5.12 of W59-13 or governing reference standard on the welding procedure data sheet shall be followed.

10.0 POSITION

The welding shall be done preferably in flat position. Welding in other position is permissible, subject to prequalified joint limitation of referenced standard or where Welding Procedure Data Sheets are supplied and approval by Canadian Welding Bureau.

11.0 ELECTRICAL CHARACTERISTICS

Shielded metal arc welding can operate over a wide range of currents and voltages depending on the type and size of electrode used. The current may be either AC or DC; thus, the power source may be either AC or DC or combination of AC/DC welder. In general, current, voltage and polarity of particular electrode should be selected as per manufacturer's published data and recommendations.

12.0 WELDING TECHNIQUE

A welder's skill in performing satisfactory weld involves: Striking the arc, maintaining short and steady arc length, making a suitable weaving motion when required and traversing the joint at correct speed of arc travel. The arc is struck by hitting or scratching the striking end of the electrode against joint surface. The electrode is held at suitable angle with respect to the work and the line of the joint, depending on the type of the joint and position of welding. The arc may be traversed along a straight line without weaving motion, or it may be weaved sideways. A bead deposited without weaving is termed as stringer bead, while that deposited with weaving is called a weave bead. At the end of the weld run, the arc is made to linger momentarily to fill up the arc crater, and the electrode withdrawn suddenly to extinguish the arc.

Welder's ability to produce defect free weld depends largely on his ability to maintain a correct weaving motion according to the type of electrode, type of joint and welding position.

13.0 WELD METAL CLEANING

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

14.0 QUALITY

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. Fillet and butt welds shall meet the desirable or acceptable fillet weld profiles shown in Figure 5.4 of CSA W5-13. 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. Arc strikes outside the area of permanent welds should be avoided on any material. When they occur in cyclically-loaded structures, the surface of the arc strike should be lightly ground and checked for soundness using the magnetic particle inspection method.

In general, the weld quality requirements stipulated under Clause 11.5.4/12.5.4 of CSA Standard W59-13 shall be met.

15.0 TREATMENT OF UNDERSIDE OF WELDING GROOVE

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 Data Sheet. Back-gouging shall produce a groove contour substantially conforming with groove profile dimensions as specified in the figures in Clause 10 of W59-13 for the welding process to be used and with the provisions of Clause 5.4.5.1 of W59-13. Its depth shall be adequate to ensure complete penetration into the previously deposited weld metal for the welding process to be used. Suitable access to the root shall be maintained.

16.0 ESSENTIAL VARIABLES

Essential variables listed in table 11 and clause 11.4.3 (W47.1-09) shall be followed for W47.1-09/W59-13 reference standard.

A Change in any of the essential variables described in W47.1-09 or respective reference standard or detailed on Welding Procedure Data Sheets shall require a new Welding Procedure Specification and / or Welding Procedure Data Sheet.