**Ref. WPS: GMAW-CS**

COMPANY NAME: _____.

COMPANY ADDRESS: _____.

# WELDING PROCEDURE SPECIFICATION (WPS) FOR GAS METAL ARC WELDING (GMAW)

## 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 steel structures which are fabricated in accordance with the terms specified in the latest editions of following Standards:

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

**- CSA W59-18-Welded Steel Construction (Metal Arc Welding)**

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

**- AWS D1.3/D1.3M-Structural Welding Code, Sheet 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 Semi-automatically using the Gas Metal Arc Welding (GMAW) process. (note: Fully Automatic application can also be used.)

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 Standards, and may consist of single or multiple passes in accordance with the accepted WPDS to which this specification refers.

**Base Metals**

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

-Steels in Groups of Table 11.1 or Table 12.1 of CSA W59-18 Standard

-Steels in Groups of Table 3.1 of AWS D1.1 Code

-Steels in Groups of Table 1.2 of AWS D1.3 Code

Other materials and/ or specifications may be welded providing WPDS are accepted by the Canadian Welding Bureau.

**Base Metal Thicknesses**

-CSA W59-18 and 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 less than 3 mm (1/8 in) in nominal thickness

Above ranges may be welded under this specification providing the respective WPDSs have been supplied and accepted for the appropriate weld size.

**Filler Metals**

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

**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 $^{o}$C (-40 $^{o}$F) or lower.

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).

The shielding gas/ wire combination shall be as shown on the accepted WPDS. 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+5-18% 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.

Please note that gas composition for B-G 49A 3 C G6 (ER49S-6) wire needs to have minimum Oxidation Equivalent of 4 (O.E.=O2%+1/2% CO2).

**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 providing the proper WPDSs are prepared and approved.

**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 WPDS.

**Minimum Preheat and Interpass Temperature**

The minimum preheat before welding will comply with Table 5.3 of the CSA Standard W59-18, Table 3.3 of the AWS D1.1 or as per Clause 7.4 and Annex A of the 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 specification, unless a specific WPDS showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

**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 the following parts of Standards:

-Section 10 of CSA W59-18: Joints that conform to the provisions of Clause 10, shall be deemed as prequalified, and therefore approved for use without performing joint welding qualification tests, provided that welding procedures also conform to Clause 4, 5, and 10

-Clause 3 of AWS D1.1: In order for a WPDS to be prequalified, conformance with all of the applicable requirements of Clause 3 shall be required.

-Clause 5 of AWS D1.3: In order for a WPDS 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 WPDS 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.

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

Back-gouging, when specified in WPDS, shall produce a groove contour substantially conforming to the pre-qualified single U-joint, as described in Clause 10, W59-18. Its depth shall be adequate to ensure complete penetration into the previously deposited weld for the welding process to be used.

**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.

-CSA W59-18: Fillet weld profiles and Groove weld profiles in butt joints shall meet the desirable or acceptable weld profiles shown in Figure 5.3 of CSA Standard W59-18. The reinforcement in groove welds shall not exceed 3 mm (1/8 in) and shall have a gradual transition to the plane of the base metal surface. In general, quality of welds will be such as to meet either the requirements of Clause 11.5.4 for statically-loaded structures or Clause 12.5.4 for cyclically-loaded structures of CSA Standard W59-18.

-CSA W47.1: Acceptable and unacceptable weld profiles are shown in Figure 14

-AWS D1.1 5.23 Weld Profiles: All welds shall meet the visual acceptance criteria of Tables 6.1 and 9.16, and shall be free from cracks, overlaps, and the unacceptable profile discontinuities exhibited in Figure 5.4, and Table 5.8, and Table 5.9, except as otherwise allowed in 5.23.1, 5.23.2, and 5.23.3

-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.

**Essential Variables**

**CSA W47.1:**

**Essential Variables are defined in CSA W47.1 Clause 11:**

**CSA W47.1: Clause 11.4.2:** Essential variables for soundness and mechanical testing shall be as specified in Table 11, Table 12 and Clause 11.4.3

**CSA W47.1: Clause 11.4.3:** The PQR mechanical test essential variable changes requiring a requalification for the GMAW 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

- For the GMAW process, a strength level greater than B-G 49A (ER49S-X) requires requalification

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

**Essential Variables when reference code in WPDS is combination of either CSA W47.1/ AWS D1.1 or CSA W47.1/ AWS D1.3:**

**AWS D1.1:**

**AWS D1.1 Table 4.5:** PQR Essential Variable Changes Requiring WPDS Requalification

Following are general changes requiring a requalification for GMAW process based on Table 4.5 of AWS D1.1, however for full detail list of essential variables, Table 4.5 of AWS D1.1 applies:

(a) a change in welding position not qualified by Table 4.1 [Plate]/ Table 9.9 [Pipe] of AWS D1.1

(b) a change in diameter or thickness or both not qualified by Table 4.2 [Plate]/Table 9.10 [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 4.8 of AWS D1.1

(e) 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 the requirements of 3.12 (PJP-Figures 3.2) or 3.13 (CJP-Figures 3.3), (9.10 or 9.11 [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 WPDS 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) 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

**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 D1.1 code or AWS D1.3, 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).

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