Welding Procedure Guide

An easy to follow guide covering the preparation of welding procedure data sheets

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1.0 Introduction

This guide has been prepared to assist welding personnel with the preparation of welding procedures required as part of their company certification to CSA Standards W47.1, W47.2 and W186.

The following three documents will be described:

(a) Welding Engineering Standards (Note: Only required for W47.2)

(b) Welding Procedure Specifications

c) Welding Procedure Data Sheets

There will be a brief description of the first two documents; however, this guide will focus on the preparation of welding procedure data sheets. Each item on the welding procedure data sheet will be described and guidance will be provided to complete each section.

2.0 Welding Engineering Standards

Welding engineering standards cover the design of welded joints encountered by the fabricator and prepared primarily for the fabricator's engineering and drafting personnel.

The welding engineering standards typically include:

(a) Illustrated profiles of each typical joint intended for use, showing:

(i) The type of joint (eg, butt, lap, tee, corner, edge);

(ii) The type of weld;

(iii) The geometry of the preparation and fit-up;

(iv) The standard welding symbol;

(v) The range of thickness; and

(b) Minimum permissible sizes of fillet and partial penetration groove welds.

Welding symbols shall be as shown in AWS Standard A2.4.

Sample welding engineering standards are available on our website www.cwbgroup.org

3.0 Welding Procedure Specification (WPS)

All companies applying or certified to CSA Standards W47.1, W47.2 or W186 are required to prepare and submit welding procedure specifications to the CWB for acceptance.

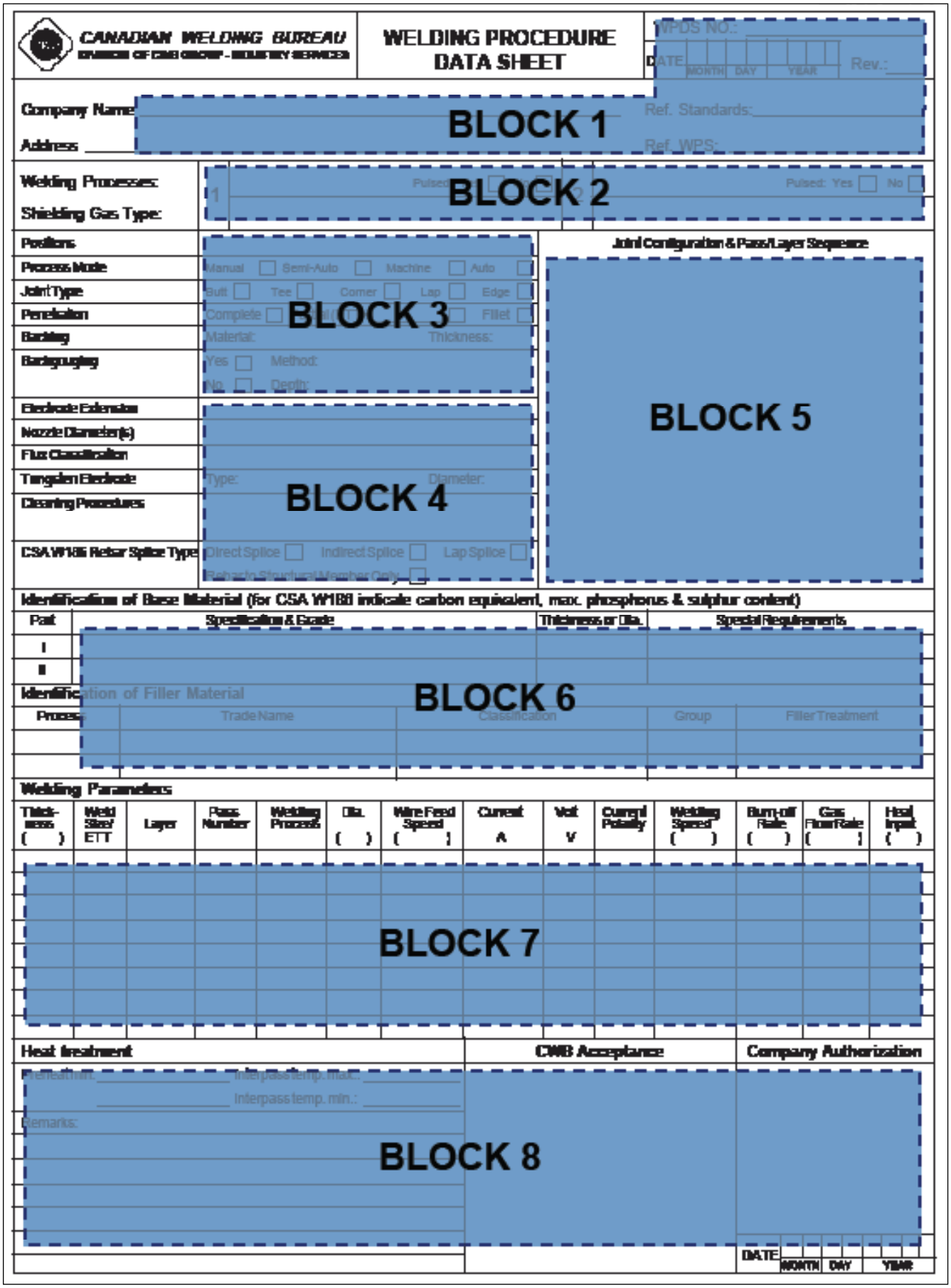
A welding procedure specification (WPS) sets broad guidelines for the shop and field welding practice of the fabricator for each anticipated combination of essential variables. Welding parameters and ranges are specified and used to prepare the associated welding procedure data sheets.

The company shall have welding procedure specifications for each welding process in use, outlining the general welding procedure to be followed in the construction of weldments built in accordance with the governing design or manufacturing standard, or both. Welding procedure specifications submitted for acceptance should cover as a minimum the items specified in Appendix D of CSA Standard W47.1 or Appendix A of CSA Standard W47.2, as applicable. Each welding procedure specification shall include applicable essential variables. All welding procedure specifications shall be submitted to the Bureau for acceptance and when stamped as accepted shall be considered as registered with the Bureau.

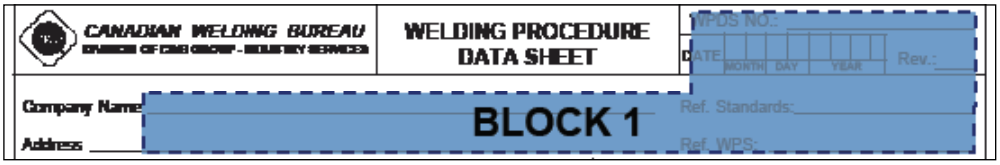
Sample welding procedure specifications are available on our website www.cwbgroup.org

4.0 Welding Procedure Data Sheet (WPDS)

A 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. The following is the standard welding procedure data sheet form suggested by the CWB, however, other welding procedure data sheet formats may be used. Each item on the data sheet will be described and guidance on the completion of the form will be given. Common errors in completing the form will be identified.



4.1 BLOCK 1 (General Information)



Company name and address

Enter the complete company name and address in this section. If the data sheets are to be used by two or more certified plants within the same company the applicable plants need to be identified in the documentation submitted.

WPDS No.

Each company should have its own method of numbering welding procedure data sheets. This can range from a relatively simple consecutive number system to one that identifies the process, position, groove type and electrode. Each welding procedure data sheet number should be unique so that the WPDS can be easily referenced on production schedules, work orders, shop drawings etc.

Date and Revision

Enter the date the welding procedure data sheet was prepared and the revision number.

Reference Standards

Some welding standards that may be referenced are:

W47.1 – Certification of Companies for Fusion Welding of Steel

W59 – Welded Steel Construction (Metal Arc Welding)

W186 – Welding of Reinforcing Bars in Reinforced Concrete Construction

W47.2 – Certification of Companies for Fusion Welding of Aluminum

W59.2 – Welded Aluminum Construction

AWSD1.1 – Structural Welding Code - Steel

AWSD1.3 – Structural Welding Code – Sheet Steel

AWSD1.6 – Structural Welding Code – Stainless Steel

A common combination is W47.1 and W59. For certified companies, there must always be a certification standard stated (eg. W47.1, W47.2,W186) plus a “Construction” standard (eg. W59, W59.2, D1.3, D1.6).

Reference WPS

Record the welding procedure specification number that applies to this data sheet.

Some common mistakes with Block 1:

- The company name and address are not completed.
- More than one data sheet has the same identification number.
- No reference code is specified.
- Reference codes are specified that have different qualification rules and essential variables. For example W59 and D1.3.

4.2 BLOCK 2 (Process information)

Welding Processes

The welding process to be used should be specified in this section. If two welding processes are used to weld the joint they can be each be entered in the areas identified “1” and “2”. Some of the common processes used are listed below with their corresponding letter designations:

Process	Letter Designation
Shielded Metal Arc Welding	SMAW
Gas Metal Arc Welding	GMAW
Flux Cored Arc Welding	FCAW
Metal Cored Arc Welding	MCAW
Gas Tungsten Arc Welding	GTAW
Submerged Arc Welding	SAW
Plasma Arc Welding	PAW
Electroslag Welding	ESW
Electrogas Welding	EGW
Stud Welding	SW

The letter designation may be used to identify the process.

Full details about the various welding processes can be found in the CWB modules.

Pulsed

If pulsed current is used check this box. Enter the root mean square (RMS) current in block 7 and the peak and background current in the remarks section of block 8. The pulsed power source brand, model name and the applicable program number should also be noted in the remarks section (Block 8).

Shielding Gas type

Record the complete generic composition or gas trade name as shown on the label on the gas cylinder.

Use of the generic composition is advantageous as it allows the user to change brands of shielding gas with the same composition with no required changes to the WPDS.

Note: If the trade name is used, a change to another brand name, even if it is of identical composition, will require revised data sheets.

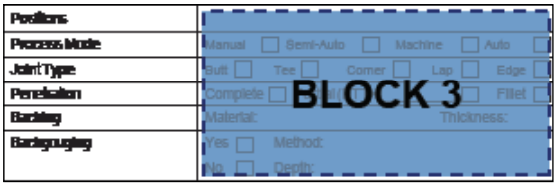
The gas manufacturer/supplier may be able to provide you with the generic composition. For gas metal arc welding, the wire is classified using 100% CO_2; however, argon-oxygen-carbon dioxide combinations may be used based on the oxygen equivalent.

For full details of gas combinations refer to CSA Standard W48.

Some common mistakes with Block 2:

- No welding process specified
- No gas composition specified
- Gas not certified with the filler material

4.3 BLOCK 3 (Joint information)



Positions

Positions shown on the data sheet should be the production position classified as Flat (F), Horizontal (H), Vertical-Up (V-U), Vertical Down (V-D) or Overhead.

Number and letter combinations are also used to designate each welding position for quick reference. The letter G stands for groove weld, letter F for fillet weld. The numbers 1, 2, 3 and 4 correspond to flat, horizontal, vertical and overhead positions respectively. For the vertical position indicate if the progression is vertical up or vertical down.

In actual shop fabrication welding can be in any intermediate position. For detailed information on the definition of the various welding positions please consult Appendix E of CSA Standard W59, Welded Steel Construction (Metal Arc Welding) or AWS A3.0, Standard Welding Terms and Definitions.

Process mode (manual, semi-automatic, machine and auto)

One of the four process modes should be checked in this section based on the following definitions. Do not enter more than one process mode unless multiple processes are used.

Manual welding. Welding with the torch, gun or electrode holder held and manipulated by hand. Accessory equipment, such as part motion devices and manually controlled filler material feeders may be used. An example is SMAW or GTAW.

Semi-automatic welding. Manual welding with equipment that automatically controls one or more of the welding conditions. Examples are FCAW, GMAW

Machine welding (mechanized welding). Welding with equipment that requires manual adjustment of the equipment controls in response to visual observation of the welding, with the torch, gun or electrode holder held by a mechanized device. SAW is an example.

Automatic welding. Welding with equipment that requires only occasional or no observation of the welding and with no manual adjustment of the equipment controls. An example is a robotic application.

Joint type

Check the box(s) to indicate the joint type. The five basic types are butt, tee, corner, lap and edge.

For definitions and details of joint type, please consult CWB Module 2, Engineering Drawings, Basic Joints and Preparation for Welding.

Penetration (complete, partial, ETT)

The depth of penetration of a groove weld needs to be identified.

A complete joint penetration groove weld is defined as one in which the weld metal extends through the joint thickness. This can be achieved with or without backing. If complete joint penetration is achieved the box marked “Complete” should be checked.

A partial joint penetration groove weld is one in which incomplete joint penetration exists. If this is the case the box marked “Partial” should be checked and the effective throat thickness (ETT) should be dimensioned in the space provided. The ETT may be specified as a percentage of T, eg. ETT = 0.75T. Table 4-3 of CSA Standard W59 shows minimum groove depths for partial joint penetration groove welds based on the thickness of the parts and the groove angle at the root. Verify that these requirements are met.

Fillet

The box marked “fillet” should be checked if the weld is a weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap-joint, T-joint or corner joint. Joints with a groove angle greater than 135 degrees or less than 30 degrees require greater detail in the sketch (defined as skewed joints). Refer to W59 Clause 4.5 for more detail.

Backing (material and thickness)

Backing is a material or device placed against the back side of the joint adjacent to the joint root to support and shield molten weld metal.

Permanent backing is designed to remain in place as part of the finished weld.

Backings used for the welding of steels up to and including 480 MPa (70 ksi) minimum specified tensile strength may be any of the steels listed in clauses 11.2.1 and 12.2.1 of CSA Standard W59.

W59 requires that backings used for the welding of steels of over 480 MPa (70 ksi) minimum specified tensile strength and shall be of the same material as the base material.

If steel backing is used enter the material and thickness of backing in the space provided

Non-permanent backings can be made from materials such as ceramic, copper or flux. If they are used enter the material, type and form of the backing in the space provided.

Back gouging (Yes/ No, Method, Depth)

Back gouging is the removal of weld metal and base metal from the weld root side of a welded joint to facilitate complete fusion and complete joint penetration upon subsequent welding from that side. Methods include grinding to sound metal (GTSM), air carbon arc and plasma.

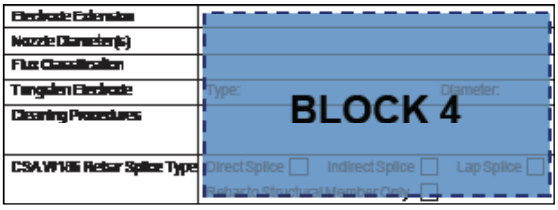
Back gouging should produce a groove contour substantially conforming to the appropriate prequalified single U-joint in Clause 10 of CSA Standard W59, and its depth should be adequate to ensure complete penetration into the previously deposited weld metal for the welding process to be used.

If back gouging is used, the back gouging box should be checked. The method used and the depth identified.

Some common mistakes with Block 3:

- No welding position specified.
- Incorrect welding position specified. For example, the drawing shows horizontal (2F or 2G) but position says “Flat”.
- Progression of welding not shown for Vertical.
- Partial joint penetration specified with ETT = T
- No ETT specified for partial joint penetration
- Both fillet and partial boxes are checked (Complete or partial joint penetration only apply to groove welds)

4.4 BLOCK 4 (Technical data)



Electrode extension

The electrode extension for the gas metal arc welding, flux cored arc welding, submerged arc welding processes is the length of electrode extending beyond the end of the contact tip.

The electrode extension for the gas tungsten arc welding and plasma arc welding processes is the length of electrode extending beyond the end of the collett.

Enter the electrode extension in this section. Do not leave it blank. If the information requested does not pertain to the welding process used insert N/A (Not Applicable) e.g. SMAW.

Nozzle diameter

The gas nozzle is the device at the exit end of the torch or gun that directs shielding gas in gas shielded processes. Enter the diameter of this nozzle in the space provided. If it does not apply (eg. non-gas shielded processes), enter N/A.

Flux classification

For the submerged arc welding (SAW) process the flux classification or flux trade name should be entered e.g. EM12K or the flux trade name. This information can be obtained from the label on the bag of flux. If you enter the flux trade name and decide later to change the flux the data sheet will need to be revised. The generic classification is preferred.

Tungsten electrodes (type, dia.)

The tungsten type and diameter used should be specified for the GTAW process. For other processes enter N/A. The choice of the type and size of tungsten electrode for a particular application depends on the operating current and current type.

Common tungsten types are listed below.

AWS CLASSIFICATION	COMMON NAME	COLOUR CODE
EWCe-2	2% Ceriated Tungsten	Orange
EWLa-1	1% Lanthanated Tungsten	Black
EWTh-1	1% Thoriated Tungsten	Yellow
EWTh-2	2% Thoriated Tungsten	Red
EWZr-1	1% Zirconiated Tungsten	Brown
EWG	Other - Needs to be Specified	Gray

Cleaning procedures

Enter the cleaning procedures used. This is particularly important for the welding of aluminum alloys because a change in cleaning method is considered an essential variable. Full details of the cleaning procedure used should be included in the corresponding welding procedure specification.

CSA W186 Rebar splice type.

This section is only used for welding procedure data sheets for CSA Standard W186- Reinforcing Bars.

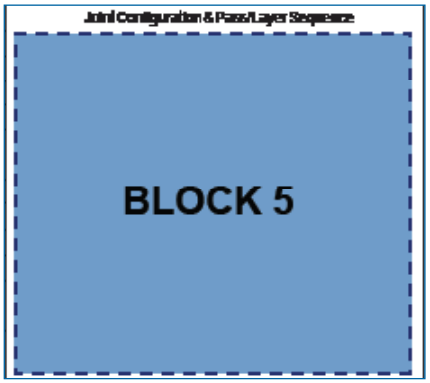
The types identified in CSA Standard W186 are:

- direct splice
- indirect splice
- lap splice
- rebar to structural member

Some common mistakes with Block 4:

- Electrode stickout not specified
- Incomplete or no cleaning procedures specified

4.5 BLOCK 5 (Joint preparation)



Joint Configuration and Pass/Layer sequence

A sketch of the joint configuration with the welding symbol and a typical sequence of the layers and passes should be included in this section of the form. It is recommended that the sketch be drawn in the correct welding postion.

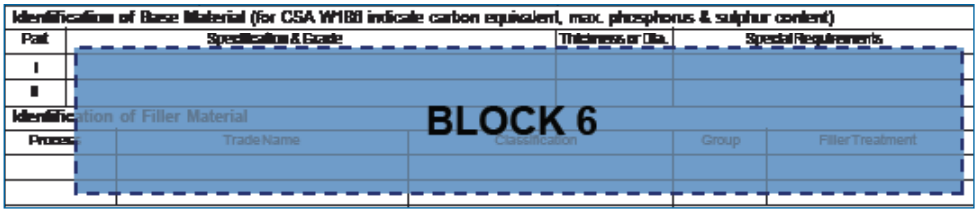
The joint configuration should include the following information:

- thickness of parts
- root opening
- root face
- bevel angle
- groove angle
- depth of preparation
- radius (for HSS)
- diameter (for solid bars/tubing/pipe)
- effective throat thickness (ETT)

Some common mistakes with Block 5:

- Missing details such as root face or land (Rf), Root gap or opening (G), groove angle (Θ), radius
- Non pre-qualified material thickness. Ex: 0.9mm GMAW wire is not pre-qualified for groove welds with a material thickness greater than 12mm.

4.6 BLOCK 6 (Base and Filler material)



Identification of base material (specification and grade, thickness or diameter, special requirements)

Obtain a copy of the mill test certificate or any other document from the material supplier that shows the specification and grade of the base materials. Record the complete material specifications and grades on the welding procedure data sheets. Check with your purchasing agent.

The following are some examples of correct and incorrect material designations:

Incorrect	Correct
44W	CSA Standard G40.21 Grade 300W
A572	ASTM A572 Grade 50
Gr. 400 Rebar	CSA Standard G30.18 Grade 400W

Note that many materials, especially ASTM materials, have a grade designation which must be included.

Another common method to designate materials on data sheets is to use steel groups such as “Steels in groups 1, 2 and 3 of Table 11-1/ 12-1 of CSA Standard W59. This is advantageous as it ensures a wide range of materials are covered.

Identification of filler material (process, trade name, classification, group, filler treatment)

Filler material classifications can be found in CSA Standard W48 “Filler metals and Allied Materials for Metal Arc Welding” or AWS Specifications:

Check the label on the filler material box or spool to obtain the full filler material classification. This information can also be verified on our website www.cwbgroup.org.

Please note there is a new designation system for wire electrodes and deposits for GMAW of non alloy and fine grained steels as specified in ISO CAN/CSA-ISO 14341.

Full details can be found in CSA Standard W48.

The commonly used classifications are B-G 49A 2 C G3 (formerly ER49S-3) and B-G 49 A 3 C G6 (formerly ER49S-G).

The electrode or electrode-flux combination for butt joints using complete joint penetration groove welds shall be in accordance with Table 11.1 or 12.1 of CSA Standard.

The electrode or electrode-flux combination for:

- complete joint penetration groove welds in joints other than butt joints;
- partial joint penetration groove welds; or
- fillet welds may be of lower or higher strength than required by Table 11.1 or 12.1, provided that the conditions of Table 11.2(a), 11.2(b), 12.2(a), or 12.2(b), as applicable, are fully satisfied.

Remember that only steels in Column 2 of Table 5-3 of CSA Standard may be welded with SMAW with other than low hydrogen electrodes and FCAW and MCAW without diffusible hydrogen designators.

The following filler material groups may be used for shielded metal arc welding (SMAW):

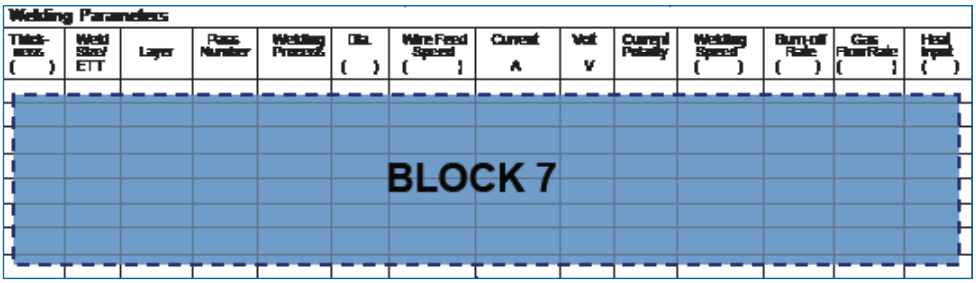
Group	Electrode Classifications
F1	EXX22, EXX24, EXX27, EXX28
F2	EXX12, EXX13, EXX14
F3	EXX10, EXX11
F4	EXX15, EXX16, EXX18, EXX48

Filler material treatment shall be in accordance with manufacturer's recommendations and the requirements of the applicable standard.

Some common mistakes with Block 6:

- The base material is not fully described. For example: 3XX Stainless Steel. A precise description must be given from the reference code such as Group A or B, Table 3.1, AWS D1.6. A precise material specification such as "ASTM A240, Grade 304L" can also be given.
- The filler material classification is incorrect.
- No thickness is specified.

4.7 BLOCK 7 (Welding details)



Thickness

Record the thickness of material to be welded in the space provided.

Weld size/ ETT

The weld size for a fillet weld or effective throat for a groove weld should be entered in this section.

Layer and pass number

Enter the number of passes and sequence of welding.There are several ways available to determine the number of layers and passes for a WPDS including:

- The Nomograph Method
- The Mathematical Equation Method
- The Weld Calculator Program Method

These methods require you to calculate the area of weld and to select a deposition rate. Deposition rates can be found in some welding textbooks, online or from your electrode supplier.

Steel and aluminum calculators, Weld_IT software, data sheet preparation courses etc. are available from the CWB to help you calculate the number of layers and passes. Details can be obtained from our website www.cwbgroup.org.

Welding Processes

Enter the number “1” or “2” identified in Block 2 or the letter designation below.

Welding Process	Letter Designation
Shielded Metal Arc Welding	SMAW
Gas Metal Arc Welding	GMAW
Flux Cored Arc Welding	FCAW
Metal Cored Arc Welding	MCAW
Gas Tungsten Arc Welding	GTAW
Submerged Arc Welding	SAW
Plasma Arc Welding	PAW
Electroslag Welding	ESW
Electrogas Welding	EGW
Stud Welding	SW

Diameter

The standard units of measurement for electrode diameter are mm in SI (metric) and inch (imperial). The following shows common electrode sizes in SI (metric) and Imperial units.

INCH	MM
0.030	0.8
0.035	0.9
0.040	1.0
0.045	1.2
1/16	1.6
5/64	2.0
3/32	2.4
1/8	3.2
5/32	4.0
3/16	5.0
1/4	6.0

Be consistent with the selection of the choice of units.

Wire feed speed

The standard units of measurement for wire feed speed are m/min in S.I. (metric) and inches/ min (imperial).

A calibrated wire feed meter is preferred for measuring wire feed speed when the actual welding is in progress. If a verification of the recorded number is necessary or a wire feed meter is not available, measure the length of wire discharged from the gun for a period of 20 seconds. Multiply the length of discharged wire by 3 to give the wire feed speed in inches/minute or meters/minute. Take care to ensure that these are the real wire feed speeds and not the run in values

Current

Current values can be found in welding textbooks, online or by contacting your electrode supplier for one of their product catalogs. The current to be used depends on many factors including electrode type, size, welding position, joint design.

Measure the amperage using a calibrated clamp type amp meter. Follow the meter manufacturer’s directions and measure the amperage as close to the gun/holder as possible without interfering with the operator. This usually is about 3 or 4 feet from the gun/holder. When measuring voltage different techniques can be used depending on the welding process being used.

Voltage

When measuring voltage, different techniques can be used depending on the welding process being used. For the SMAW and GMAW processes the voltage can be taken between the cable terminals on the welding machine.

For the GMAW and FCAW processes, the voltage can be taken between the work lead at the work connection clamp and the electrode lead at the the contractor in the wire feed unit. If not practical, the voltage can also be taken between terminal or between the cable terminals on the welding machine.

For the SAW process, the voltage can be taken between the electrode lead connection at the torch and the work lead clamp.

Warning-Welding parameters should only be measured by properly trained personnel following safe work practices. Follow manufacturers recommendations.

Current Polarity

Enter the current and polarity for the electrode, electrode-gas or electrode- flux combination being used. This information can be found in welding textbooks (CWB Learning Centre Module 4), electrode standards, online or from electrode catalogues or from your supplier.

Direct current electrode positive (DCEP) is the arrangement of direct current welding leads in which the electrode is the positive pole and the work piece is the negative pole of the welding arc. A non standard term for this is direct current reverse polarity.

Direct current electrode negative (DCEN) is the arrangement of direct current welding leads in which the electrode is the negative pole and the work piece is the positive pole of the welding arc. A non standard term for this is direct current straight polarity.

Alternating current is the current flow in an electrical circuit, usually at a pre-determined frequency.

Arc Travel Speed/ Welding Speed

The arc travel speed can be measured by recording the time taken to weld a specific length of weld, then convert the measured time and length to inches/minute or millimeters/minute. Record the calculated arc travel speed (ATS) value and not just the measured length and time. This can be done using one of the following formulas:

$$\text{ATS (ins/min)} = \frac{\text{Measured Weld Length in inches} \times 60}{\text{Measured Time in Seconds}}$$

or

$$\text{ATS (mm/min)} = \frac{\text{Measured Weld Length in millimeters} \times 60}{\text{Measured Time in Seconds}}$$

Burn-off rate

The burn off or melting rate is the weight or length of electrode, wire, rod, powder melted in a unit of time. Record this information for arc spot welds.

Gas flow rate

The shielding gas flow rate should be high enough to maintain adequate shielding for the arc but not so high that it causes turbulence in the weld pool. The gas flow rate to be used depends on a number of factors such as the process, welding position, shielding gas, electrode extension and operating parameters. With GTAW, flow rates are typically in the range of 15 to 20 cubic feet per hour (CFH). With GMAW and FCAW flow rates typically vary between 25 and 45 CFH depending on the factors noted above. Manufacturer's literature should be consulted for more details.

The standard units of measurement for gas flow rate are l/min in S.I. (metric) and cubic feet/ hr CFH (imperial). To convert from CFH to L/min multiply by 0.472. To convert from L/min multiply by 2.119.

CFH	15	20	25	30	35	40	45
L/min.	7	9.5	12	14	16.5	19	21

Check the gas flow rate with a meter and record the rate and the unit of measurement (in brackets).

Heat input

Enter the heat input and the unit of measurement when the heat input needs to be controlled. Examples are when welding quenched and tempered steels and when specific impact properties need to be achieved.

Heat input is the energy supplied by the welding arc to the work piece. The heat input is calculated using the following formula:

$$H = \frac{V \times A \times 60}{1000 \times T}$$

where:

H = heat input (kJ/in or kJ/mm)

V = arc voltage (volts)

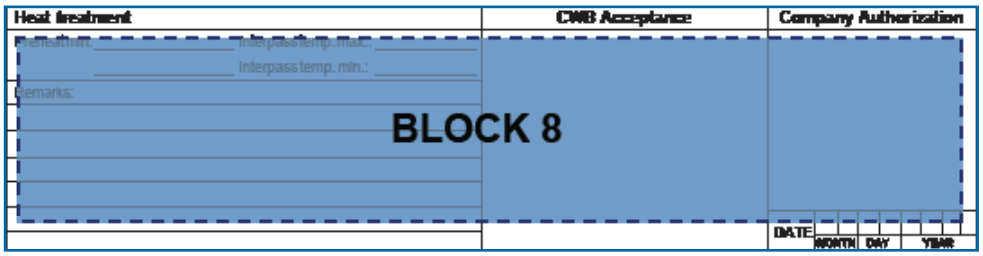
A = current (amps)

T = travel speed (in/min or mm/min)

Some common mistakes with Block 7:

- No wire feed speed with a semi-automatic process. (This is one adjustment the welder needs to make)
- Incorrect voltage or wire feed speed parameters for GMAW spray arc transfer. Charts showing parameters for spray transfer are available from the CWB
- Incomplete range of fillet weld sizes
- Incorrect number of welding passes in flare-bevel or flare-V joints. Ex: 8 welding passes to get an 8mm effective throat
- No flow rate entered
- Flow rate unit written “CFM” instead of “CFH”

4.8 BLOCK 8 (Final remarks)



Heat treatment (preheat, interpass temperatures, post weld heat treatment)

For preheat or interpass temperatures refer to the applicable table in the standard such as Table 5-3, CSA Standard W59. Alternatively enter the values in Centigrade or Fahrenheit. This box cannot be left empty or marked as ambient or not applicable (N/A).

If a post weld heat treatment is used the temperature and time should be recorded.

Additional remarks

Any additional remarks or requirements should be added in this section. It can also be used for notes if there is insufficient space in other sections of the welding procedure data sheet form. Examples are details of pulsed welding or welding techniques such as stringer or weave beads.

Company authorization

The developed welding procedures need to be accepted by the responsible personnel at the company before submission to the CWB.

For companies involved in certification to CSA Standard W47.1 - Division 1 or 2, their welding procedures must indicate the acceptance by the designated welding engineer. Engineers submitting welding procedures to the CWB must, at their option, seal and/or sign each document.

For companies involved in certification to CSA Standard W47.2 - Division 1, 2.1 or 2.2, CSA Standard W186, their welding procedures must indicate the acceptance by the designated professional engineer responsible for welding procedures and practice. Engineers submitting welding procedures to the CWB must, at their option, seal and/or sign each document.

For companies involved in certification to CSA Standard W47.1 - Division 3 or CSA Standard W47.2 - Division 3 their welding procedures must indicate the acceptance by a qualified welding supervisor. Welding supervisors submitting welding procedures to the CWB must sign each document.

For Division 3 companies, when the welding supervisor changes the company's approved welding procedures are still considered valid. The company is not required to submit the existing welding procedures for re-approval or provide an acceptance letter. The new welding supervisor is tested on the knowledge and application of the company's welding procedures.

When a company changes its status from Division 3 to Division 1, 2 (W47.1) or 2.1 or 2.2 (W47.2), or when an engineer takes over the responsibilities for previously approved welding procedures, the engineer may, at his or her discretion, use one or more of the following options:

- prepare and submit for approval new welding procedures bearing his or her seal and/or signature;
- issue a dated and signed letter to the CWB listing all welding procedures previously approved by the CWB that have been reviewed and found to be acceptable for the company's operations.
- review, sign and/or seal the existing documents and resubmit the appropriate number of copies for re-approval. If the welding supervisor's or engineer's signature or the engineer's seal has been removed from the document then the previous approval must also be removed. If the previous approval stamp has not been removed the documents are returned to the engineer without being reviewed.
- if the engineer does not submit any documentation to the Bureau regarding the existing procedures, it is presumed that the engineer has reviewed the procedures and found them to be suitable for the company's welding operations. The engineer is not required to advise the Bureau of the action he or she has taken.

When a company changes its status from Division 1 or 2 to Division 3, the company's existing approved welding procedures are still considered valid. The company may submit the existing welding procedures for re-approval or provide an acceptance letter, although this is not a requirement.

Date

The data sheet should have an accepted date.

Some common mistakes with Block 8:

- Welding procedure data sheets are not accepted by the authorized personnel.
- Preheat is entered as "none" or ambient.
- Incorrect Preheat is specified.

4.8 CHECKLIST: The following checklist can be used for completing welding procedure data sheets.

WELDING PROCEDURE DATA SHEET ITEM	SMAW	GMAW	FCAW	MCAW	GTAW	SAW
General Information						
Company name and address	X	X	X	X	X	X
WPDS No.	X	X	X	X	X	X
Date and Rev	X	X	X	X	X	X
Process Information						
Reference Standards	X	X	X	X	X	X
Welding Process	X	X	X	X	X	X
Pulsed current		X	X	X	X	
Shielding gas type		X	X	X	X	
Joint Information						
Positions	X	X	X	X	X	X
Process mode	X	X	X	X	X	X
Joint type	X	X	X	X	X	X
Penetration	X	X	X	X	X	X
Fillet	X	X	X	X	X	X
Backing material and thickness	X	X	X	X	X	X
Back gouging	X	X	X	X	X	X
Technical information						
Electrode extension		X	X	X		X
Flux classification						X
Tungsten electrode					X	
Cleaning	X	X	X	X	X	X
Joint preparation						
Joint configuration/ joint type	X	X	X	X	X	X
Base and filler material						
Identification to standard or group	X	X	X	X	X	X
Identification of filler material	X	X	X	X	X	X
Welding details						
Thickness	X	X	X	X	X	X
Weld size	X	X	X	X	X	X
Layers	X	X	X	X	X	X
Pass No.	X	X	X	X	X	X
Welding Process	X	X	X	X	X	X
Diameter	X	X	X	X	X	X
Wire feed speed		X	X	X		X
Voltage	+	X	X	X	+	X
Current, Current Type/ polarity	X	X	X	X	X	X
Arc travel speed	+	X	X	X	+	X
Gas flow rate		X	X	X	X	X
Additional items						
Heat treatment/ preheat/ interpass	X	X	X	X	X	X
Additional remarks						
Company authorization	X	X	X	X	X	X
Charpy V-notch						
Reference standard	X	X	X	X	X	X
Heat input	X	X	X	X	X	X
Stringer or weave bead	X	X	X	X	X	X
Arc Spot welds						
Visible diameter	X				X	
Coating thickness	X				X	

+ If heat input control is required

5.0 Submission Of Welding Procedures

A certified company is required by the Standard to submit welding procedure data sheets, to the CWB, for the types of welded joints used by the company.

Electronic submissions of welding procedures should be sent to procedures@cwbgroup.org.

Hard copy submissions should be sent to the Procedures Department, 7250 West Credit Ave., Mississauga, ON L5N 5N1.

A WPDS can be accepted based on the following:

- The joint geometry and parameters are specified by the governing standard to be prequalified
- The company has previous procedure qualification test data recorded on a PQR (procedure qualification record)
- There are successful procedure data sheet tests in the CWB database that match the information on your WPDS
- By successfully passing procedure qualification tests conducted in accordance with the requirements of the applicable standard
- By successfully passing procedure qualification tests conducted in accordance with other recognized specifications or standards
- By successfully passing a special procedure qualification test recorded on a PQR (an alternative type test)

The requirements for procedure qualification testing will be identified by the Procedure Engineer in a letter sent to the client.

6.0 Review And Approval Of Welding Procedures

General

Each submission is reviewed by a Procedure Engineer based on the requirements of the applicable standards and/or codes. The applicable standard and/ or code must be referred on the document submitted.

The Procedure Engineers use their professional discretion when reviewing all documents to ensure that they are feasible and meet the requirements as set out in the certification standards.

When a Welding Procedure Data Sheet meets all prequalified requirements but does not seem feasible soundness tests are required.

In cases not directly covered by the certification standards, the Procedure Engineers apply the general concepts of the standard combined with the requirements of other relevant standards and codes to complete the review and approval process.

Welding Engineering Standards

Welding Engineering Standards when required are stamped received.

Welding Procedure Specifications

Welding procedure specifications that satisfy the requirements specified in the applicable standard are stamped accepted.

Welding procedure specifications submitted for approval shall include, as a minimum, the applicable essential variables of the governing design or manufacturing standard.

Welding Procedure Data Sheets

Prequalified Joints: Welding procedure data sheets, using joints designated as prequalified in the governing standard, can be accepted by the CWB as prequalified without further testing by the company, provided all other requirements of the governing standard have been met. Examples of governing standards that designate joints as prequalified are CSA Standard W59 and AWS Code D1.1.

Approval using the CWB database: Welding procedure data sheets that are not prequalified in the governing standard can be accepted by the CWB if sufficient relevant testing information has been accumulated by the CWB. The CWB reviews all submitted Welding Procedure Data Sheets that are not prequalified against the information in our database. This database contains procedure qualification tests completed by companies, and if sufficient information is found, acceptance can be granted without procedure testing. Welding Procedure Data Sheets that satisfy these requirements are stamped accepted on the basis of previous tests accumulated by the CWB.

Non Prequalified Joints - Procedure Testing: Welding procedure data sheets that are not prequalified in the governing standard can be accepted by the Bureau if relevant procedure qualification testing is completed by the company and witnessed by the CWB. The requirements for procedure qualification testing are identified by the Procedure Engineer in a letter sent to the client. Welding procedure data sheets that are successfully tested are stamped accepted to the applicable standard on the basis of procedure qualification.

More than one qualification standard/code specified on the Welding Procedure Data Sheet: If there is more than one standard/code, the requirements of all specified standards/codes must be met. For example: A fillet weld Welding Procedure Data Sheet with both CSA W47.1 and AWS D1.6, will required 3 macro-etch tests.

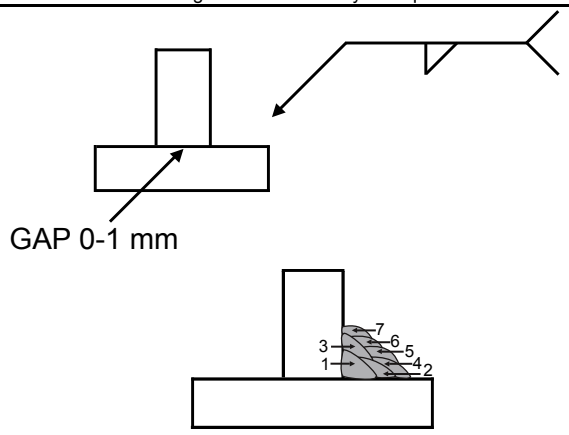
7.0 Sample Welding Procedure Data Sheets

CANADIAN WELDING BUREAU	**WELDING PROCEDURE DATA SHEET**	WPDS NO.: SMAW-2F-8 DATE: 5/27/2008 Rev.: 0

Company Name:	Canadian Welding Bureau		Ref. Standards:	CSA W47.1/ W59
Address:	7250 West Credit Avenue, Mississauga, ON L5N 5N1		Ref. WPS:	SMAW-1

Welding Processes:	1	SMAW Pulsed: ☐ Yes ☑ No	2		Pulsed: ☐ Yes ☑ No
Shielding Gas Type:		N/A			
Positions:	Horizontal				
Process Mode:	☑ Manual ☐ Semi-Auto ☐ Machine ☐ Auto				
Joint Type:	☐ Butt ☑ Tee ☐ Corner ☐ Lap ☐ Edge				
Penetration:	☐ Complete ☐ Partial ETT=		☑ Fillet		
Backing:	Material: N/A		Thickness: N/A		
Backgouging:	☐ Yes Method:				
	☑ No Depth:				
Electrode Extension:	N/A				
Nozzle Diameter(s):	N/A				
Flux Classification:	N/A				
Tungsten Electrode:	Type: N/A		Dia.:		
Cleaning Procedures	Use a chipping hammer and wire brush. Slag shall be removed from all finished welds and before welding over previously deposited metal.				
CSA W186 Rebar Splice Type:	☐ Direct Splice ☐ Indirect Splice ☐ Lap Splice ☐ Rebar to Structural Member Only				

Joint Configuration & Pass/Layer Sequence



Identification of Base Material (for CSA W186 indicate carbon equivalent, max. phosphorus & sulphur content)

Part	Specification & Grade	Thickness or Dia.	Special Requirements
I	Steels in Groups 1, 2 and 3 of Table 11-1/ 12-1	5.0 mm - 16.0 mm	
II	Steels in Groups 1, 2 and 3 of Table 11-1/ 12-1	5.0 mm - 16.0 mm	

Identification of Filler Material

Process	Trade Name	Classification	Group	Filler Treatment
SMAW		E49 8	F4	Cl. 5.2.2.4, W59

Welding Parameters

Thick-ness ( )	Weld Size/ ETT	Layer	Pass Number	Welding Process	Dia. (mm)	Wire Feed Speed ( )	Current A	Volt V	Current Polarity	Welding Speed ( )	Burn-Off Rate ( )	Gas Flow Rate ( )	Heat Input ( )
	5.0	1	1	SMAW	3.2	N/A	120-140		AC/DC+			N/A	
	6.0	1	1	SMAW	3.2	N/A	120-140		AC/DC+			N/A	
	8.0	1-2	1-3	SMAW	3.2	N/A	120-140		AC/DC+			N/A	
	10.0	1-2	1-4	SMAW	4.0	N/A	160-180		AC/DC+			N/A	
	12.0	1-3	1-6	SMAW	4.0	N/A	160-180		AC/DC+			N/A	
	16.0	1-3	1-7	SMAW	4.0	N/A	160-180		AC/DC+			N/A	

Heat treatment :			
Preheat min:	10° C	Interpasstemp.max.:	
		Interpasstemp.min.:	10° C
Remarks: Preheat in accordance with Table 5-3 of CSA W59			

CWB Acceptance

Company Authorization

To be signed by the engineer or supervisor before submission to the CWB

Date: 5/27/2008

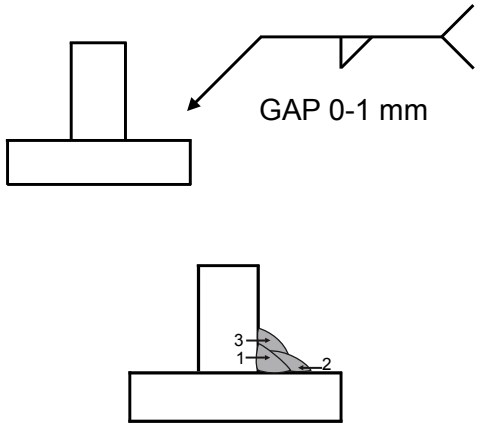
WELDING PROCEDURE DATA SHEET

WPDS NO.: GMAW-2F
DATE: 5/27/2008 Rev.: 0

Company Name: Canadian Welding Bureau
Address: 7250 West Credit Avenue, Mississauga, ON L5N 5N1
Ref. Standards: CSA W47.1/ W59
Ref. WPS: GMAW-1

Welding Processes:	1	GMAW	Pulsed: ☐ Yes ☑ No	2	Pulsed: ☐ Yes ☐ No
Shielding Gas Type:		90%Ar/ 10% CO2			
Positions:	Horizontal				
Process Mode:	☐ Manual ☑ Semi-Auto ☐ Machine ☐ Auto				
Joint Type:	☐ Butt ☑ Tee ☐ Corner ☐ Lap ☐ Edge				
Penetration:	☐ Complete ☐ Partial ETT=		☑ Fillet		
Backing:	Material: N/A	Thickness:			
Backgouging:	☐ Yes	Method:			
	☑ No	Depth:			
Electrode Extension:	20 mm				
Nozzle Diameter(s):	16 mm				
Flux Classification:	N/A				
Tungsten Electrode:	Type: N/A	Dia.:			
Cleaning Procedures	Wire brush, clean between passes				
CSA W186 Rebar Splice Type:	☐ Direct Splice ☐ Indirect Splice ☐ Lap Splice ☐ Rebar to Structural Member Only				

Joint Configuration & Pass/Layer Sequence



Identification of Base Material (for CSA W186 indicate carbon equivalent, max. phosphorus & sulphur content)

Part	Specification & Grade	Thickness or Dia.	Special Requirements
I	ASTM A36, A516 Gr. 70 G40.21Gr. 300W, 350 W	6-10 mm	N/A
II	ASTM A36, A516 Gr. 70 G40.21Gr. 300W, 350 W	6-10 mm	N/A

Identification of Filler Material

Process	Trade Name	Classification	Group	Filler Treatment
GMAW	N/A	E[illegible]A 3 C G6 (ER49S-6)	N/A	Cl. 5.2.4.5, CSA W59

Welding Parameters

Thick-ness ( )	Weld Size/ ETT	Layer	Pass Number	Welding Process	Dia. (mm)	Wire Feed Speed (m/min)	Current A	Volt V	Current Polarity	Welding Speed (mm/min)	Burn-Off Rate ( )	Gas Flow Rate (l/min	Heat Input ( )
	6	1	1	GMAW	1.2	10.0	260	28	DC+	400-500		20	
	8	1	1	GMAW	1.2	10.0	260	28	DC+	300-400		20	
	10	1	1	GMAW	1.2	10.0	260	28	DC+	400-500		20	
		2	2-3	GMAW	1.2	10.0	260	28	DC+	400-500		20	

Heat treatment :

Preheat min: 10° C
Interpasstemp.max.: 250° C
Interpasstemp.min.: 10° C
In accordance with Table 5-3, CSA Standard W59

CWB Acceptance

Company Authorization

To be signed by the engineer or supervisor before submission to the CWB

Date: 5/27/2008

COMPANY NAME: __ _____

COMPANY ADDRESS:_ __ _____

WELDING PROCEDURE SPECIFICATION
FOR SHIELDED METAL ARC WELDING
OF STAINLESS STEEL

SPECIFICATION No.:_____

Scope

This Welding Procedure Specification covers welding and related operations of stainless steel, which are fabricated in accordance with CSA W47.1 and AWS D1.6. The attached data sheets form an essential part of this specification. CSA Standard W59 may be referenced when joining stainless steel to carbon steel.

A change in any of the essential variables contained in the succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet(s) will require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

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 indicated on the accepted Welding Procedure Data sheets referring to this specification.

Base Metal

The base metals used shall conform to ASTM austenitic stainless steel specifications as noted on the Welding Procedure Data Sheets welded to each other or to carbon steels conforming to the specifications of steel groups 1,2 and 3 as per table 11-1 or table 12-1 of CSA W59 . Other grades of stainless steel and carbon steel may be welded provided accepted Welding Procedure Data Sheets are available.

Base Metal Thickness

Base metal from 2.0 mm (1/16 in.) to unlimited thickness may be welded under this specification provided that the Welding Procedure Data Sheets have been supplied and accepted by the Canadian Welding Bureau. Thicknesses less than 2.0 mm(1/16 in.) may be welded providing data sheets have been accepted by the Canadian Welding Bureau.

	X
CWB	**ENGINEER OR SUPERVISOR**

X This space to be stamped by P. Eng. if Div. 1 or Div. 2 company. Welding Supervisor's Signature if Div. 3 company.

Filler Metal

Filler metal shall be certified by the Canadian Welding Bureau as conforming to the requirements of CSA Standard W48-01.

The choice of filler metal shall be in accordance with the following table or as shown on the CWB accepted Welding Procedure Data Sheet.

Base Metal	304L	308	309	309S	310	310S	316 316H	316L	317	321 321H	347 347H 348 348H
304 304H 305	308	308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308	308
304L	304L	308	308 309	308 309	308 309 310	308 309 310	308 316	308L 316L	308 316 317	308L 347	308L 347
308		308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308 347	308 347
309			309	309	309 310	309 310	309 316	309 316	309 316	309 347	309 347
309S				309S	309 310	309S 310S	309 316	309S 316L	309 316	309 347	309 347
310					310	310	310 310Mo 316	310 310Mo 316	310 310Mo 317	308 310	308 310
310S						310S	310Mo 316	310Mo 316	310Mo 317	308 310	308 310
316H 316							316	316	316 317	308 316 347	308 316 347
316L								316L	317	316L 347	316L 347
317									317	308 317 347	308 317 347
321 321H										321	308L 347

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

The welding shall preferably be done in the flat position. The horizontal, vertical and overhead positions may be used provided accepted Welding Procedure Data Sheets referring to those positions and the Welding Procedure Specification are followed.

Preheat

Preheat does not normally apply to the welding of austenitic stainless steel, but if required, details will be shown on the specific Welding Procedure Data Sheet(s).

Electrical Characteristics

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

MANUFACTURER'S RECOMMENDED WELDING PARAMETERS

This table shows the recommended parameters for all electrodes to be covered by this specification.

Electrode Classification	Electrode Diameter	Position	Amperage	Polarity	Voltage

Welding Technique

Refer to the Welding Procedure Data Sheet for the precise SMAW variables to be used in welding a particular thickness and 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.

Preparation of Base Material

The edges or surfaces of parts to be joined by welding shall be prepared by shear or plasma arc 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.

Weld 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.

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. All welds shall be free from overlap.

In general, the weld quality will be such as to meet the requirements of Clause 6.28 and 6.29 of AWS D 1.6 standard.

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. Cracks or blemishes caused by arc strike shall be ground to a smooth contour and examined visually to assure complete removal.

Treatment of Underside of Groove

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged to sound metal unless otherwise specified on an applicable Welding Procedure Data Sheet, accepted by the Canadian Welding Bureau.

Essential Variables

The variables listed in Table 4.1 of AWS D1.6 are considered, as essential variables .Any of the essential variable changes listed in Table 4.1 require requalification of the Welding Procedure Data Sheet.

Welding Procedure Data Sheets

The attached Welding Procedure Data Sheets form part of this specification.

COMPANY NAME:_____.

COMPANY ADDRESS:_____.

WELDING PROCEDURE SPECIFICATION FOR SUBMERGED ARC WELDING

SPECIFICATION No.:_____.

Scope

This Welding Procedure Specification covers welding and related operations of steel structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1 and W59, latest revisions. The attached Data Sheets form an essential part of this specification.

A change in any of the essential variables contained in succeeding paragraphs or detailed on applicable Welding Procedure Data Sheet(s) shall require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

The welding shall be done by the Submerged-Arc Process using either automatic or semi-automatic equipment, with single or multiple arcs as indicated on the Welding Data Sheets.

Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

Base Metal

The base metal shall conform to the specifications of steel groups 1, 2, 3 as per Table 11.1 or Table 12.1 of CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted by the Canadian Welding Bureau.

Base Metal Thickness

Base metal thicknesses from 3 mm (1/8") to UNLIMITED THICKNESS inclusive may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

CWB Acceptance	**Engineer or Supervisor Acceptance**

Filler Metal/Flux

The electrode and flux to be used in combination shall conform to the requirements of CSA Standard W48. Any combination of electrodes and fluxes not certified by the CWB shall be subject to procedure qualification.

Storage and Conditioning of Electrodes/Fluxes

Electrodes 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 inches 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

The welding shall be done only in the position indicated on the Welding Data Sheet.

Preheat

The minimum preheat before welding will comply with Table 5.3 of CSA Standard W59. 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, 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 Data Sheet showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

Electrical Characteristics

The current used shall be either direct current (DC) or alternating current (AC) as indicated on the Welding Data Sheets.

Welding Technique

The correct amperage and voltage, speed of travel, thickness of layers, number of passes, position, material electrodes and any special instructions will be as per Data Sheet.

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 that will 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.

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 Standard W59. 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 In general, the weld quality will be such as to meet the requirements of Clause 11.5.4/12.5.4 of CSA Standard W59.

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.

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.

COMPANY NAME:_____.

COMPANY ADDRESS:_____.

WELDING PROCEDURE SPECIFICATION FOR SHIELDED METAL ARC WELDING

SPECIFICATION No.:_____.

Scope

This Welding Procedure Specification covers welding and related operations of steel structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1 and W59, latest revisions. The attached Data Sheets form an essential part of this specification.

A change in any of the essential variables contained in succeeding paragraphs or detailed on applicable Welding Procedure Data Sheet(s) shall require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

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

Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

Base Metal

The base metal shall conform to the specifications of steel groups 1, 2, 3 as per Table 11.1 or Table 12.1 of CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted by the Canadian Welding Bureau.

Base Metal Thickness

Base metal thicknesses from 3 mm (1/8") to UNLIMITED THICKNESS inclusive may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

CWB Acceptance	**Engineer or Supervisor Acceptance**

Filler Metal

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

Storage and Conditioning of Electrodes

Basic Electrodes

The storage and conditioning of electrodes shall be as per CSA Standard W59.

All basic electrodes shall be delivered in hermetically sealed containers that do not show evidence of damage. However, if such containers show evidence of damage, the electrodes shall be reconditioned in accordance with the requirements of CSA Standard W59.

Immediately after being removed from hermetically sealed containers or from reconditioning ovens, electrodes shall be stored in ovens held at a temperature of at least 120°C (250°F).

Basic electrodes of E49XX classification that are not used within 4 hours after removal from ovens shall be reconditioned in accordance with the requirements of CSA Standard W59.

Basic electrodes shall be re-dried no more than once.

Electrodes that have been wet shall be discarded.

Other Than Basic Electrodes

All other than basic 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.

Electrodes that have been wet shall be discarded.

Position

The welding shall be done preferably in the flat position, but other positions such as horizontal, vertical and overhead are permissible providing the proper Data Sheets are supplied and approved.

Preheat

The minimum preheat before welding will comply with Table 5.3 of CSA Standard W59. 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, 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 Data Sheet showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

Electrical Characteristics

Welding equipment will be used having a drooping voltage characteristic. The welding current specified will be direct current (straight or reverse polarity) or alternating current. The current range will be as per electrode manufacturer's instructions and will shown on the Welding Procedure Data Sheet.

Welding Technique

The correct amperage and voltage, speed of travel, thickness of layers, number of passes, position, material electrodes and any special instructions will be as per Data Sheet.

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

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 that will 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.

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 Standard W59. 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 In general, the weld quality will be such as to meet the requirements of Clause 11.5.4/12.5.4 of CSA Standard W59.

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.

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.

COMPANY NAME: _____

COMPANY ADDRESS:_____

W47.1/AWS D1.6

WELDING PROCEDURE SPECIFICATION
FOR GAS TUNGSTEN ARC WELDING
OF STAINLESS STEEL

SPECIFICATION No.:_____

Scope

This Welding Procedure Specification covers welding and related operations of stainless steel, which are fabricated in accordance with CSA Standard W47.1 and AWS D1.6. The attached data sheets form an essential part of this specification. CSA Standard W 59 may be referenced when joining stainless steels to carbon steels.

A change in any of the essential variables contained in the succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet will require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet.

Welding Process

The welding shall be done using the Gas Tungsten Arc Welding (GTAW) process.

Joints shall be made by single or multiple pass welding, from one or both sides, as indicated on the approved Welding Procedure Data sheets referring to this specification.

Base Metal

The base metals used shall conform to ASTM austenitic stainless steel specification as noted on the Welding Procedure Data Sheets welded to each other or to carbon steels conforming to the specifications of steel groups 1,2 and 3 as per table 11-1 or table 12-1 of CSA W59. Other grades of stainless steel and carbon steel may be welded provided accepted Welding Procedure Data Sheets are available

Base Metal Thickness

Base metal from 2.0 mm(1/16 in.) to unlimited thickness may be welded under this specification provided that the Welding Procedure Data Sheets have been supplied and approved by the Canadian Welding Bureau. Thicknesses less than 2.0 (1/16 in.) mm may be welded providing data sheets have been approved by the Canadian Welding Bureau.

	X
CWB	**ENGINEER OR SUPERVISOR**

X This space to be stamped by P. Eng. if Div. 1 or Div. 2 company. Welding Supervisor's Signature if Div. 3 company.

Filler Metal

Tungsten electrodes conforming to AWS classification shall be used. The filler metal meeting the requirements of the latest addition of AWS A 5.9 classification shall be selected to weld base material on the basis of matching chemical analysis as nearly as possible.

Filler metal shall be stored in a dry, clean place adequately protected from the weather or environment hazards until actually needed. The storage area temperature shall be maintained at a uniform temperature approximately the same as that of the welding location.

The choice of filler metal shall be in accordance with the following table or as shown on the CWB accepted Welding Procedure Data Sheet.

Base Metal	304L	308	309	309S	310	310S	316 316H	316L	317	321 321H	347 347H 348 348H
304 304H 305	308	308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308	308
304L	304L	308	308 309	308 309	308 309 310	308 309 310	308 316	308L 316L	308 316 317	308L 347	308L 347
308		308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308 347	308 347
309			309	309	309 310	309 310	309 316	309 316	309 316	309 347	309 347
309S				309S	309 310	309S 310S	309 316	309S 316L	309 316	309 347	309 347
310					310	310	310 310Mo 316	310 310Mo 316	310 310Mo 317	308 310	308 310
310S						310S	310Mo 316	310Mo 316	310Mo 317	308 310	308 310
316H 316							316	316	316 317	308 316 347	308 316 347
316L								316L	317	316L 347	316L 347
317									317	308 317 347	308 317 347
321 321H										321	308L 347

Shielding Gas

The shielding gas shall be welding grade argon, helium, or an argon-helium mixture and shall be limited to those specified on the fabricator's approved Welding Procedure Data Sheets. The welding gases shall have a dew point of -40° Celsius, or lower, at 101 kPa.

The gas distribution system shall be free from leaks to prevent air or other contaminants from entering. The containers or storage systems should not be used when the pressure falls below 2000 kPa (290 psi). *

Position

The welding shall preferably be done in the flat position. The horizontal, vertical and overhead positions may be used provided approved Welding Procedure Data Sheets referring to those positions and the Welding Procedure Specification are followed.

Preheat

Preheat does not normally apply to the welding of austenitic stainless steel, but if required, details will be shown on the specific data sheet(s).

Electrical Characteristics

The welding shall be done using a DC power source with drooping volt-ampere characteristics on straight polarity.

MANUFACTURER'S RECOMMENDED WELDING PARAMETERS

This table shows the recommended parameters for all electrodes to be covered by this specification.

Shielding Gas	Electrode Classification	Position	Amperage	Polarity	voltage	Stick-out

Welding Technique

Refer to the Welding Procedure Data Sheet for the precise GTAW 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.

Before welding is started, electrode size, current setting and gas flow should be selected to suit the material thickness and welding position being used from an approved data sheet.

Preparation of Material

The edges or surfaces of parts to be joined by welding shall be prepared by shear or plasma arc 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.

Weld 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 shown in Clause 5.11 of AWS D1.6.

All welds shall be free of cracks.

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 6.29 and 6.29 of AWS D1.6. All welds shall be free from overlap.

In general, the weld quality will be such as to meet the requirements of Clause 6.28 and 6.29 of AWS D1.6.

Essential Variables

The variables listed in Table 4.1 of AWS D1.6 are considered, as essential variables .Any of the essential variable changes listed in Table 4.1 require requalification of the Welding Procedure Data Sheet.

Welding Procedure Data Sheets

The attached Welding Procedure Data Sheets form part of this specification.

COMPANY NAME:

COMPANY ADDRESS:

WELDING PROCEDURE SPECIFICATION
FOR SHIELDED METAL ARC WELDING OF ARC SPOT WELDS

SPECIFICATION No.:

Scope

This welding procedure specification covers arc spot welding and related operations for attaching sheet steel to structural steel in accordance with the latest editions of CSA Standards W47.1 and W59, and AWS D1.3. "Structural Welding Code - Sheet Steel".

Welding Procedures

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

Base Metal

Supporting steel shall conform to the specifications of steel groups 1, 2, and 3 of table 11-1 of CSA W59. Galvanized sheet steel shall conform to ASTM A446 or CSSBI 101M.

Base Metal Thickness

Sheet material from __ Ga to __ Ga and supporting steel from 3 mm (1/8") to __ mm (__") may be welded under this specification. The thickness of a single sheet or the combined thickness of multiple sheets welded to a supporting member shall not exceed 3.7 mm (0.15"). Welding procedure data sheets showing thicknesses of material will be supplied to and accepted by the Canadian Welding Bureau.

Filler Metal

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

	X
CWB	**ENGINEER OR SUPERVISOR**

X This space to be stamped by P. Eng. if Div. 1 or Div. 2 company.
Welding Supervisor's Signature if Div. 3 company.

Storage and Conditioning of Electrodes

Basic Electrodes

All basic electrodes shall be delivered in hermetically sealed containers that do not show evidence of damage. However, if such containers show evidence of damage, the electrodes shall be dried for at least 1 hour at a temperature between 370°C (700°F) and 430°C (800°F) before being used or otherwise treated as non-basic electrodes.

Immediately after being removed from hermetically sealed containers or from drying ovens, electrodes shall be stored in ovens held at a temperature of at least 120°C (250°F).

Basic electrodes of E49XX (E70XX) classification that are not used within 4 hours after removal from ovens shall be reconditioned in accordance with the requirements of Clause 5.2.2.4.1. of CSA W59.

Basic electrodes shall be redried no more than once.

Other Than Basic Electrodes

All other than basic 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.

Electrodes that have been wet shall be discarded.

Position

Welding shall be done in the positions indicated on the approved Welding Procedure Data Sheet.

Preheat

Preheat is not normally required when arc spot welding sheet steel to thicker supporting members. Reference Clause 5.2.2.3. and Appendix K of CSA W59.

Electrical Characteristics

Welding current will be direct or alternating. The current range and polarity will be as shown on the approved data sheets.

Essential Variables

A change in the following variables shall be considered essential changes and shall required establishing a new procedure by qualification (Clause 4.5 of AWS D1.3):

1. A change in the classification of electrode.
2. A change in the size of electrode.
3. A change increasing the filler metal strength level.
4. A change in the type of current or polarity.
5. An increase of more than 10% in the melting rate or amperage from both that used in the procedure qualification test.

6. An decrease of more than 5% in the melting rate or amperage from both that used in the procedure qualification test.
7. A change in thickness of sheet steel by more than 10%.
8. A change in the type of coating material on the sheet steel.
9. An increase exceeding 30% in the thickness of coating of the sheet steel.
10. A change from a single layer to a double layer of sheet steel or vice versa.
11. A change in the welding position.

Welding Technique

The electrode should be at right angles to the decking. The arc is struck and a short arc maintained. A spiral motion is used increasing in size until the required weld size is attained, the electrode is then drawn back to the centre of the weld and the arc is broken off.

Preparation Of Base Material

Surfaces to be welded shall be dry, clean and free from loose scale, oil or grease.

The decking shall be fitted tightly to the supporting member before welding begins. A chalk line will be used to locate welds over the supporting member. Spacing of the welds will be as shown on the design or erection drawings.

Welding will not be carried out when the ambient temperature is less than -18°C (0°F) or when surfaces are exposed to rain, snow or high winds.

Quality

The welds will be circular, and have a minimum nugget diameter of 13 mm (1/2"). At least 87.5% of the circumference will be fully fused to the supporting member as per AWS D1.3. **The welds will be filled to a slightly convex contour.**

Burn through of supporting members is not permitted. If this does occur, it shall be reported to the responsible engineer and repairs will be made under his/her direction to ensure joint integrity.

Welds shall be uniform in appearance and shall be free of overlap, cracks, porosity and excessive undercut.

Weld washers shall be used to prevent burn back for sheet steels thinner than 0.7 mm (0.028"). Separate procedure qualification tests will be required for arc spot welds using weld washers.

Weld Metal Cleaning

All slag remaining shall be removed from the finished welds.

For galvanized decking a coat of zinc rich primer shall be applied to the finished weld.

Welder Qualifications

Welders will be qualified under clause 4 of AWS D1.3. The welding procedure used in the qualification shall be a qualified welding procedure. The following is an outline of the limitations of welder qualification which should only be used together with AWS D1.3.

Base Metal

Qualification to any one of the steels covered by this procedure specification shall be considered qualification to weld any other sheet steels covered by this procedure specification, providing that they have no coating or have the same coating used in the qualification. Separate qualification is required for galvanized sheet steel.

Base Metal Thickness

For arc spot welding, the welder shall qualify separately for each thickness (gauge) of sheet steel to be used.

Electrodes

A welder qualified to weld with an electrode in the following table shall be considered qualified for any electrode in the same group, and any electrode listed in a numerically lower group.

GROUP	ELECTRODE
F4	EXX15, EXX16, EXX18
F3	EXX10, EXX11
F2	EXX12, EXX13, EXX14

Position

The welder shall be qualified separately for each position of welding.

Welder Tests Required

The following table describes the welder test requirements.

TABLE 1 WELDER QUALIFICATION TEST

Test Assembly	Type of:		Qualifies For:			Number of Tests	Type of Test
	Joint	Position	Position	Joint	Thickness		
See Figure 1	Arc spot weld, sheet to supporting member	F	F	Arc spot weld and arc seam weld, sheet to supporting member	Thickness tested	2	Twist

Figure 1.

Test Results Required

The sheet steel shall be struck with a hammer until the steel around the weld separates, due to failure in the weld or in the steel. The nugget diameter shall be measured to ensure that it meets the minimum required diameter (13 mm (1/2")). The melting rate for the electrode used shall be measured. The test shall then be repeated for a total of two successful tests.

COMPANY NAME: _____.

COMPANY ADDRESS:

WELDING PROCEDURE SPECIFICATION FOR GAS METAL ARC WELDING

SPECIFICATION No.: GMAW-1 .

Scope

This Welding Procedure Specification covers welding and related operations of steel structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1 and W59, latest revisions. The attached Data Sheets form an essential part of this specification.

A change in any of the essential variables contained in succeeding paragraphs or detailed on applicable Welding Procedure Data Sheet(s) shall require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

The welding shall be done semi-automatically using the GMAW (Gas Metal Arc Welding) process.

Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

Base Metal

The base metal shall conform to the specifications of steel groups 1, 2, 3 as per Table 11.1 or Table 12.1 of CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted by the Canadian Welding Bureau.

Base Metal Thickness

Base metal thicknesses from 3mm (1/8") to UNLIMITED THICKNESS inclusive may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

CWB Acceptance	**Engineer or Supervisor Acceptance**

Filler Metal

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

Storage and Conditioning of Electrodes

Electrodes 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°C (-40°F) or lower. The shielding gas/electrode combination shall be as shown on the accepted Welding Procedure Data Sheets.

Welding 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).

Position

The welding shall be done preferably in the flat position, but other positions such as horizontal, vertical and overhead are permissible providing the proper Data Sheets are supplied and approved.

Preheat

The minimum preheat before welding will comply with Table 5.3 of CSA Standard W59. 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, 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 Data Sheet showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

Electrical Characteristics

The welding current shall be direct current (reverse polarity) using a constant voltage type power supply. The range of parameters will be as per electrode manufacturer's instructions and will shown on the Welding Procedure Data Sheet.

Welding Technique

Refer to the Data Sheet for the precise GMAW 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.

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.

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 Standard W59. 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 In general, the weld quality will be such as to meet the requirements of Clause 11.5.4/12.5.4 of CSA Standard W59.

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.

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.

COMPANY NAME: _____.

COMPANY ADDRESS: _____.

W47.2/W59.2

WELDING PROCEDURE SPECIFICATION FOR GAS METAL ARC WELDING OF ALUMINUM

SPECIFICATION No.:_____

Scope

This Welding Procedure Specification covers welding and related operations of aluminium structures which are fabricated in accordance with the terms outlined in CSA Standard W47.2 and W59.2. The attached Data Sheets form an essential part of this specification.

A change in any of the essential variables contained in the succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet(s) shall require a new (or revised) Welding Procedure Specification and/or a new (or revised) Data Sheet.

Welding Procedure

The welding shall be done semi-automatically using the G.M.A.W. (Gas Metal Arc Welding) process.

Joints shall be made by following the procedural stipulations indicated in CSA W59.2, and may consist of single or multiple passes in accordance with the approved Welding Procedure Data Sheets to which this specification refers.

Base Material

The base metal alloys used should conform to the materials listed in Table 5 of CSA Standard W59.2.

Other alloys may be welded provided the appropriate Welding Procedure Data Sheets have been approved.

	X
CWB	**ENGINEER OR SUPERVISOR**

X *This space to be stamped by P. Eng. if Div. 1 or Div. 2 company. Welding Supervisor's Signature if Div. 3 company.*

Base Material Thickness

Base metal thicknesses from 3.0 mm (1/8") to unlimited thickness may be welded under this specification provided that the Welding Procedure Data Sheets have been supplied and approved by the Canadian Welding Bureau. Other thicknesses (t < 3 mm) may be welded providing the above condition is met.

Filler Material

The filler metal shall be certified by the Bureau as conforming to the requirements of ANSI/AWS Standard A5.10.

The choice of filler metal shall be in accordance with Table 3 (W59.2), unless otherwise approved by the engineer. *

Storage and Conditioning of Electrodes

Filler metal shall be stored in the original package in a dry, clean, heated place adequately protected from the weather or environment hazards until actually needed at the fabrication site. The storage area temperature shall be maintained at a uniform temperature approximately the same as that of the welding location.*

Precautions shall be taken to ensure that all opened packages of spools of electrode wire are protected from the weather or other contaminants. Filler metals that are contaminated with foreign matter shall not be used.*

Shielding Gas

The shielding gas shall be welding grade argon, helium, or an argon-helium mixture and shall be limited to those specified on the approved welding procedure data sheets. No additions of other gases shall be acceptable. The welding gases shall have a dew point of - 40□ C, or lower, at 15 MPa.*

Shielding gases shall be stored in and used from the containers in which they are supplied or from a central storage tank distribution system which is replenished by the gas supplier. No gas shall be transferred from one tank to another in the plant.*

The distribution system shall be free from leaks to prevent air or other contaminants from entering. The containers or storage systems should not be used when the pressure falls below 2000 kPa (290 psi).*

Welding Position

The welding shall be done preferably in the flat position. The horizontal, vertical and overhead positions may be used provided approved Welding Procedure Data Sheets referring to those positions and the Welding Procedure Specification are followed.

Preheat/Heat Treatable Alloys

Preheat is not normally required when fusion welding aluminium; however, when welding thick aluminium sections, preheating is sometimes used to avoid cold-start defects to achieve heat balance between dissimilar thickness or to remove moisture. Care shall be taken to ensure temperature control, particularly, when fabricating the heat treatable alloys and the 5XXX series alloys that contain more than 3% magnesium. Preheating temperatures for these types of alloy shall not exceed 120□ Celsius. Holding time at this temperature shall not exceed 15 minutes.

When welding heat treatable alloys and 5XXX alloys containing more than 3% magnesium, the interpass temperature shall be allowed to fall below 150□ Celsius before starting the nextpass.*

Electrical Characteristics

The welding current shall be direct current reverse polarity using a constant voltage type power supply.

MANUFACTURER'S RECOMMENDED WELDING PARAMETERS

Shielding Gas	Electrode Classification	Weld Position	Diameter	Amperage	Voltage	Wire Feed Speed

Welding Technique

Refer to the Data sheet for the precise GMAW variables to be used in welding a particular thickness and joint configuration, position and parameters, i.e. stick-out, gas flow, travel speed, passes and layers, etc.

The selection of the welding gun angle depends on joint type, material thickness, edge preparation, in addition to the degree of skill and experience of the operator.

For groove welding, the gun is angled from 10□ to 15□ to produce a forehand angle.

When GMA welding aluminum, the gun must never be dragged (have a backhand angle).

The proper angle is important as it affects depth of penetration, weld contour and gas shielding. The angle may be varied slightly, depending on the arc travel speed, welding position, size of weld required and welding current. In application, where welding is done at high speed, the forehand angle may be greater.

Vertical welding must always be done in the upward direction with a forehand angle in range of 10□ to 15□ .

For fillet welding lap and tee joints, the torch bisects the 90□ angle made by the joint and has a forehand angle of 10□ to 15□ in the direction of travel.

When welding pieces of dissimilar thickness, the gun should be directed towards the heavier member.

Preparation of Base Metal

Edge preparation shall be accomplished by disc grinding, shearing, plasma-arc cutting, sawing, chipping, planing, milling, routing, or other method approved by the engineer.*

When disc grinding is used for edge preparation, high speed flexible grinding discs shall be used. The grinding disc shall be maintained free of lubricants and other foreign material.*

When shearing is used for edge preparation the shear blade shall be kept sharp and free of foreign material. The sheared edge of aluminum shall be filed, planed or routed to remove any metal that can possibly entrap foreign material such as cutting oil.*

To allow effective cleaning, surfaces and edges to be welded shall be smooth, uniform, and free from fins, cracks, and other defects that could introduce porosity or oxides into the weld.*

When plasma arc cutting is used for the edge preparation of heat-treatable alloys, 3 mm of material shall be removed from the cut edges by mechanical means. This includes both butt and T-joints.*

Note: Plasma arc cutting of heat treatable aluminum alloys may produce lamellar fissures.*

In plasma arc cutting of non-heat-treatable alloys, the arc shall be adjusted and directed to avoid cutting beyond the prescribed lines. Surface roughness of the cut surfaces shall be no greater than 25 um for material up to 100 mm thick and 50 um for material 100-200 mm thick, except that the ends of members not subject to calculated stress at the ends may meet the surface roughness value of 50 um. Roughness exceeding the permissible amount and occasional notches or gouges greater than 5 mm deep on otherwise satisfactory surfaces shall be flared into the cut surface by machining or grinding to a slope not exceeding 1 in 10.*

At cut edges, occasional notches or gouges less than 10 mm deep in material up to 100 mm thick, or less than 15 mm deep in material thicker than 100 mm may, with the engineer's approval, be repaired by welding.*

The removal of temporary welds or of unacceptable work and the backgouging of welds may be effected by machining, sawing, air carbon arc, plasma arc, or impact chipping.*

Backgouging 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 metal.*

Reentrant corners shall have a radius of not less than 10 mm. The corner radius and its adjacent cuts shall meet without offset and without cutting past the point of tangency.*

All surfaces to be welded shall be wire brushed to remove oxides. In multi-pass welds the weld bead shall be wire brushed between passes. The brushes (stainless steel) shall be kept exclusively for use on aluminum.

Note: Equipment used for preparing aluminum should be used solely for this purpose to prevent contamination of the base material from foreign materials.

Cleaning should be done just prior to welding but if welding is delayed, the cleaned material shall be covered with polyethylene sheet, paper or other protective covering, to guard against contamination.

Weld Quality

Insufficient throat is not permitted.*

Weld termination craters shall not be permitted.*

If the surface finishing reveals porosity then the section shall be inspected for internal porosity.*

Welds shall be free from cracks, lack of fusion, lack of penetration, and essential free from undercut, overlap, or surface porosity.*

Continuous undercut depth shall not exceed the smaller of T/5 of 1 mm on each side of the joint, where T is the member thickness.*

Isolated undercut shall not exceed 2 mm in depth. Undercut greater than 1 mm in depth shall not have a length greater than 15 mm.*

Groove weld reinforcement at the centre of the weld shall not exceed the values given in Figure 10(a) and (b) of W59.2. If present, shall be built up uniformly to blend into the surface of the base metal to a maximum at the centre of the weld.*

When butt joints are used to join members differing in thickness, there shall be a smooth transition between the offset surfaces with a length of taper not less than four times the difference in thickness.*

Fillet welds shall have a degree of convexity not exceeding 0.1s + 1.5 mm where s = size of the minimum leg length in mm.*

Fillet welds shall conform to the profiles shown in Fig. 11 of W59.2. Fillet welds shall be free of the defects shown in Fig. 11 of W59.2.*

Welds shall not be peened.

Treatment of Underside of Welding Groove

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged, ground, or chipped to sound metal, unless otherwise specified on the applicable Data Sheet.

Essential Variables

The following are considered essential variables for Gas Metal Arc Welding (GMAW) (Clause 8.2.3.4 of CSA W47.2):

(1) a change of base metal alloy group (see Table 1A);
(2) a change of filler metal alloy group (see Table 1B);
(3) the omission of aluminum backing material or the substitution of other than aluminum backing material;
(4) a change in current of ±10% and/or arc voltage of ±2 V;
(5) a change from constant dc current to pulsed dc current or vice versa;
(6) a change of ±25% from the specified travel speed;
(7) a change of ±25% in the specified preheat;
(8) a change from a single gas to any other single gas; a change from a single gas to a mixture of gases or vice versa; a change of ±10% in specified composition of gas mixture;
(9) an increase of 50% or more, or a decrease of 20% or more, in the flow rate of shielding gas;
(10) a change in the nominal diameter of the electrode wire;
(11) a change in welding position except as provided for in Clause 8.3.1;
(12) a change in direction of progression in vertical welding;
(13) a change in specified joint geometry;
(14) a change from welding from one side to welding from both sides or vice versa;
(15) the omission, but not the inclusion, of back gouging; and
(16) a change of cleaning procedure (see Appendix E)

Data Sheets

The attached data sheets form part of this specification.**

BIBLIOGRAPHY

Those items marked with an asterisk have been extracted in whole or in part from:

CSA W59.2-M1991 WELDED ALUMINIUM CONSTRUCTION,
CANADIAN STANDARDS ASSOCIATION 1991, REXDALE, ONTARIO, CANADA.

Those items marked with a double asterisk have been extracted in whole or in part from:

CSA W47.2-M1987 CERTIFICATION OF COMPANIES FOR FUSION WELDING OF ALUMINIUM,
CANADIAN STANDARDS ASSOCIATION, 1987, REXDALE, ONTARIO, CANADA

COMPANY NAME: _____

COMPANY ADDRESS:_____

W47.1/AWS D1.6

WELDING PROCEDURE SPECIFICATION
FOR GAS METAL ARC WELDING
OF STAINLESS STEEL

SPECIFICATION No.:_____

Scope

This Welding Procedure Specification covers welding and related operations of stainless steel, which are fabricated in accordance with CSA W47.1 and AWS D1.6. The attached data sheets form an essential part of this specification. CSA Standard W59 may be referenced when joining stainless steel to carbon steel.

A change in any of the essential variables contained in the succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet(s) will require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

The welding shall be done using the Gas Metal Arc Welding (GMAW) process.

Joints shall be made by single or multiple pass welding, from one or both sides, as indicated on the accepted Welding Procedure Data sheets referring to this specification.

Base Metal

The base metals used shall conform to ASTM austenitic stainless steel specifications as note on the Welding Procedure Data Sheets welded to each other or to carbon steels conforming to the specifications of steel groups 1,2 and 3 as per table 11-1 or table 12-1 of CSA W59. Other grades of stainless steel and carbon steel may be welded provided accepted Welding Procedure Data Sheets are available.

Base Metal Thickness

Base metal from 2.0 mm (1/16 in.) to unlimited thickness may be welded under this specification provided that the Welding Procedure Data Sheets have been supplied and accepted by the Canadian Welding Bureau. Thicknesses less than 2.0 mm (1/16 in.) may be welded providing data sheets have been accepted by the Canadian Welding Bureau.

	X
CWB	**ENGINEER OR SUPERVISOR**

X This space to be stamped by P. Eng. if Div. 1 or Div. 2 company. Welding Supervisor's Signature if Div. 3 company.

Filler Metal

Filler metal shall be certified by the Canadian Welding Bureau as conforming to specifications for Stainless Steel Electrodes for Gas Metal Arc Welding under AWS A5.9.

The choice of filler metal shall be in accordance with the following table or as shown on the CWB accepted Welding Procedure Data Sheet.

Base Metal	304L	308	309	309S	310	310S	316 316H	316L	317	321 321H	347 347H 348 348H
304 304H 305	308	308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308	308
304L	304L	308	308 309	308 309	308 309 310	308 309 310	308 316	308L 316L	308 316 317	308L 347	308L 347
308		308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308 347	308 347
309			309	309	309 310	309 310	309 316	309 316	309 316	309 347	309 347
309S				309S	309 310	309S 310S	309 316	309S 316L	309 316	309 347	309 347
310					310	310	310 310Mo 316	310 310Mo 316	310 310Mo 317	308 310	308 310
310S						310S	310Mo 316	310Mo 316	310Mo 317	308 310	308 310
316H 316							316	316	316 317	308 316 347	308 316 347
316L								316L	317	316L 347	316L 347
317									317	308 317 347	308 317 347
321 321H										321	308L 347

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.

Position

The welding shall preferably be done in the flat position. The horizontal, vertical and overhead positions may be used provided accepted Welding Procedure Data Sheets referring to those positions and the Welding Procedure Specification are followed.

Preheat

Preheat does not normally apply to the welding of austenitic stainless steel, but if required, details will be shown on the specific Welding Procedure Data Sheet(s).

Electrical Characteristics

Welding equipment will be used having a constant voltage characteristic. The welding current specified will be direct current electrode positive or alternating current.

MANUFACTURER'S RECOMMENDED WELDING PARAMETERS

This table shows the recommended parameters for all electrodes to be covered by this specification.

Electrode Classification	Electrode Diameter	Position	Amperage	Polarity	Voltage

Welding Technique

Refer to the Welding Procedure Data Sheet for the precise GMAW 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.

Preparation of Base Material

The edges or surfaces of parts to be joined by welding shall be prepared by shear or plasma arc 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.

Weld 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.

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. All welds shall be free from overlap.

In general, the weld quality will be such as to meet the requirements of Clause 6.28 and 6.29 of AWS D 1.6 standard.

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. Cracks or blemishes caused by arc strike shall be ground to a smooth contour and examined visually to assure complete removal.

Treatment of Underside of Groove

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged to sound metal unless otherwise specified on an applicable Welding Procedure Data Sheet, accepted by the Canadian Welding Bureau.

Essential Variables

The variables listed in Table 4.1 of AWS D1.6 are considered, as essential variables .Any of the essential variable changes listed in Table 4.1 require requalification of the Welding Procedure Data Sheet.

Welding Procedure Data Sheets

The attached Welding Procedure Data Sheets form part of this specification.

COMPANY NAME: _____.

COMPANY ADDRESS: _____.

WELDING PROCEDURE SPECIFICATION FOR FLUX AND METAL CORED ARC WELDING

SPECIFICATION No.:_____.

Scope

This Welding Procedure Specification covers welding and related operations of steel structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1 and W59, latest revisions. The attached Data Sheets form an essential part of this specification.

A change in any of the essential variables contained in succeeding paragraphs or detailed on applicable Welding Procedure Data Sheet(s) shall require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

The welding shall be done semi-automatically using the FCAW (Flux Cored Arc Welding) or MCAW (Metal Cored Arc Welding) process.

Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

Base Metal

The base metal shall conform to the specifications of steel groups 1, 2, 3 as per Table 11.1 or Table 12.1 of CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted by the Canadian Welding Bureau.

Base Metal Thickness

Base metal thicknesses from 3 mm (1/8") to UNLIMITED THICKNESS inclusive may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

CWB Acceptance	**Engineer or Supervisor Acceptance**

Filler Metal

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

Storage and Conditioning of Electrodes

Electrodes 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°C (-40°F) or lower. The shielding gas/electrode combination shall be as shown on the accepted Welding Procedure Data Sheets.

Flux cored arc welding with external gas shielding 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).

Position

The welding shall be done preferably in the flat position, but other positions such as horizontal, vertical and overhead are permissible providing the proper Data Sheets are supplied and approved.

Preheat

The minimum preheat before welding will comply with Table 5.3 of CSA Standard W59. 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, 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 Data Sheet showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

Electrical Characteristics

The welding current shall be direct current (straight or reverse polarity) using a constant voltage type power supply. The range of parameters will be as per electrode manufacturer's instructions and will be shown on the Welding Procedure Data Sheet.

Welding Technique

Refer to the Data Sheet 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.

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.

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 Standard W59. 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 In general, the weld quality will be such as to meet the requirements of Clause 11.5.4/12.5.4 of CSA Standard W59.

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.

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.

COMPANY NAME: _____.

COMPANY ADDRESS: _____.

WELDING PROCEDURE SPECIFICATION FOR GAS METAL ARC WELDING

SPECIFICATION No.:_____.

Scope

This Welding Procedure Specification covers welding and related operations of steel structures which are fabricated in accordance with the terms outlined in CSA Standards W47.1, W59, and AWS D1.3 latest revisions. The attached Data Sheets form an essential part of this specification.

A change in any of the essential variables contained in succeeding paragraphs or detailed on applicable Welding Procedure Data Sheet(s) shall require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

The welding shall be done semi-automatically using the GMAW (Gas Metal Arc Welding) process.

Joints shall be made following the procedural stipulations indicated in CSA Standard W59, and may consist of single or multiple passes in accordance with the accepted Welding Procedure Data Sheets to which this specification refers.

Base Metal

The base metal shall conform to the specifications of steel groups 1, 2, 3 as per Table 11.1 or Table 12.1 of CSA Standard W59. Other groups may be welded providing Welding Procedure Data Sheets are accepted by the Canadian Welding Bureau.

Base Metal Thickness

Base metal thicknesses from 16Ga to UNLIMITED THICKNESS inclusive may be welded under this specification providing the respective Welding Procedure Data Sheets have been supplied and accepted for the appropriate weld size.

CWB Acceptance	**Engineer or Supervisor Acceptance**

Filler Metal

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

Storage and Conditioning of Electrodes

Electrodes 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°C (-40°F) or lower. The shielding gas/electrode combination shall be as shown on the accepted Welding Procedure Data Sheets.

Welding 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).

Position

The welding shall be done preferably in the flat position, but other positions such as horizontal, vertical and overhead are permissible providing the proper Data Sheets are supplied and approved.

Preheat

The minimum preheat before welding will comply with Table 5.3 of CSA Standard W59. 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, 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 Data Sheet showing all the parameters is submitted to the Canadian Welding Bureau and acceptance is obtained.

Electrical Characteristics

The welding current shall be direct current (reverse polarity) using a constant voltage type power supply. The range of parameters will be as per electrode manufacturer's instructions and will shown on the Welding Procedure Data Sheet.

Welding Technique

Refer to the Data Sheet for the precise GMAW 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.

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.

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 Standard W59. 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 In general, the weld quality will be such as to meet the requirements of Clause 11.5.4/12.5.4 of CSA Standard W59.

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.

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.

COMPANY NAME: _____

COMPANY ADDRESS: _____

W47.1/AWS D1.6

WELDING PROCEDURE SPECIFICATION FOR FLUX CORED ARC WELDING OF STAINLESS STEEL

SPECIFICATION No.:_____

Scope

This Welding Procedure Specification covers welding and related operations of stainless steel, which are fabricated in accordance with CSA W47.1 and AWS D1.6. The attached data sheets form an essential part of this specification. CSA Standard W59 may be referenced when joining stainless steel to carbon steel.

A change in any of the essential variables contained in the succeeding paragraphs or detailed on an applicable Welding Procedure Data Sheet(s) will require a new Welding Procedure Specification and/or a new Welding Procedure Data Sheet(s).

Welding Procedure

The welding shall be done using the Flux Cored Arc Welding (FCAW) process.

Joints shall be made by single or multiple pass welding, from one or both sides, as indicated on the accepted Welding Procedure Data sheets referring to this specification.

Base Metal

The base metals used shall conform to ASTM austenitic stainless steel specifications as noted on the Welding Procedure Data Sheets welded to each other or to carbon steels conforming to the specifications of steel groups 1,2 and 3 as per table 11-1 or table 12-1 of CSA W59. Other grades of stainless steel and carbon steel may be welded provided accepted Welding Procedure Data Sheets are available.

Base Metal Thickness

Base metal from 2.0 rrim (1/16 in.) to unlimited thickness may be welded under this specification provided that the Welding Procedure Data Sheets have been supplied and accepted by the Canadian Welding Bureau. Thicknesses less than 2.0 mm (1/16 in.) may be welded providing data sheets have been accepted by the Canadian Welding Bureau.

	X
CWB	**ENGINEER OR SUPERVISOR**

X This space to be stamped by P. Eng. if Div. 1 or Div. 2 company. Welding Supervisor's Signature if Div. 3 company.

Filler Metal

Filler metal shall be certified by the Canadian Welding Bureau as conforming to specifications for Stainless Steel Electrodes for Flux Cored Arc Welding under AWS A5.22.

The choice of filler metal shall be in accordance with the following table or as shown on the CWB accepted Welding Procedure Data Sheet.

Base Metal	304L	308	309	309S	310	310S	316 316H	316L	317	321 321H	347 347H 348 348H
304 304H 305	308	308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308	308
304L	304L	308	308 309	308 309	308 309 310	308 309 310	308 316	308L 316L	308 316 317	308L 347	308L 347
308		308	308 309	308 309	308 309 310	308 309 310	308 316	308 316	308 316 317	308 347	308 347
309			309	309	309 310	309 310	309 316	309 316	309 316	309 347	309 347
309S				309S	309 310	309S 310S	309 316	309S 316L	309 316	309 347	309 347
310					310	310	310 310Mo 316	310 310Mo 316	310 310Mo 317	308 310	308 310
310S						310S	310Mo 316	310Mo 316	310Mo 317	308 310	308 310
316H 316							316	316	316 317	308 316 347	308 316 347
316L								316L	317	316L 347	316L 347
317									317	308 317 347	308 317 347
321 321H										321	308L 347

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 been removed from their containers.

Position

The welding shall preferably be done in the flat position. The horizontal, vertical and overhead positions may be used provided accepted Welding Procedure Data Sheets referring to those positions and the Welding Procedure Specification are followed.

Preheat

Preheat does not normally apply to the welding of austenitic stainless steel, but if required, details will be shown on the specific Welding Procedure Data Sheet(s).

Electrical Characteristics

Welding equipment will be used having a constant voltage characteristic. The welding current specified will be direct current electrode positive or alternating current.

MANUFACTURER'S RECOMMENDED WELDING PARAMETERS

This table shows the recommended parameters for all electrodes to be covered by this specification.

Electrode Classification	Electrode Diameter	Position	Amperage	Polarity	Voltage

Welding Technique

Refer to the Welding Procedure Data Sheet for the precise FCAW 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.

Preparation of Base Material

The edges or surfaces of parts to be joined by welding shall be prepared by shear or plasma arc 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.

Weld 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.

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. All welds shall be free from overlap.

In general, the weld quality will be such as to meet the requirements of Clause 6.28 and 6.29 of AWS D 1.6 standard.

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. Cracks or blemishes caused by arc strike shall be ground to a smooth contour and examined visually to assure complete removal.

Treatment of Underside of Groove

Prior to depositing weld metal on the underside of a welding groove, the root shall be gouged to sound metal unless otherwise specified on an applicable Welding Procedure Data Sheet, accepted by the Canadian Welding Bureau.

Essential Variables

The variables listed in Table 4.1 of AWS D1.6 are considered, as essential variables .Any of the essential variable changes listed in Table 4.1 require requalification of the Welding Procedure Data Sheet.

Welding Procedure Data Sheets

The attached Welding Procedure Data Sheets form part of this specification.

COMPANY NAME: _____

COMPANY ADDRESS: _____

W47.2/W59.2

WELDING ENGINEERING STANDARDS
W.E.S. & GENERAL SPECIFICATION

General Notes

This Welding Engineering Standard is prepared in accordance with CSA W47.2-1987.

All welding shall be performed in accordance with the requirements of CSA W47.2-1987 and conditions laid down in CSA Standard W59.2-1991 or latest revisions to the above mentioned Standards.

All welders and welding operators shall be qualified in accordance with CSA W47.2. They shall be allowed to weld only in the level (I, II or III), category (F, H, V, O), process and electrode group for which they are qualified.

Any welding fabrication sub-contracted by this Company shall be sublet only to companies certified by the Canadian Welding Bureau under CSA W47.2. The subcontractor's CWB approved procedures may be used if satisfactory to the prime fabricator, otherwise the fabricator may provide the approved procedures for use on pertinent sub-contracted work.

Changes or revisions in welding standards shall be submitted to the Bureau for approval in accordance with Clause 3.6 of CSA Standard W47.2.

Only welding consumables certified by the Canadian Welding Bureau to AWS A5.10 shall be used. Each welding Procedure Data Sheet will designate the filler alloy to be used for the joint, the applicable codes and the number of the Welding Procedure Specification which governs the Data Sheet applications.

Aluminium base metal to be welded by this firm shall conform to the requirements of Clause 3.5 of CSA W59.2. Refer to Table 1 for allowable base metals and matching filler alloys.

	X
CWB	ENGINEER OR SUPERVISOR

X *This space to be stamped by P. Eng. if Div. 1 or Div. 2 company.*
Welding Supervisor's Signature if Div. 3 company.

Unless called for otherwise on a specific Data Sheet, vertical welds shall be made with the progression of each pass in an upward direction. If welds are to be made in a vertical down sequence, the operator and procedure shall be qualified on a separate basis.

All surfaces to be welded shall be free from water stain, excessive aluminium oxide, paint, grease cutting fluids and moisture or any other material that may cause porosity, or adversely affect the quality of welds.*

All surfaces to be welded, after having been cleaned of oil and grease, shall be scratch-brushed before welding to remove excessive oxide. In multi pass welds the weld bead and adjacent area shall be scratch-brushed between passes. A hand or power-driven stainless steel wire brush shall be used. The brushes shall be kept exclusively for use with Aluminium and be kept clean and free from contaminants.*

Welding shall not be done when the adjacent metal temperature within a distance not less than the metal thickness or 75mm is lower than 0°C. Maximum temperatures shall not exceed those specified in Clause 5.14* of W59.2.

The operator and the work shall be adequately protected against the direct effect of wind, rain and snow.*

Welding shall not be done when the work surfaces are damp.*

NOTE: Information pertaining to the following items shall be detailed on the welding procedure data sheets submitted to the CWB for approval:

1) *Profile of typical joint to be welded*
2) *Type of joint (i.e. butt, corner, tee, etc.)*
3) *Type of weld*
4) *Preparation and fit-up*
5) *Weld Symbol*
6) *Thickness range.*

Fillet Welds

Acceptable and Defective Profiles

Refer to Figure 1.

Minimum and Maximum Fillet Sizes Permissible

The minimum fillet size shall be given by the least of

t or (t/5 + 3), or 6mm

where

t = the thickness of the thicker material, mm *

The maximum fillet size permitted along the edge of a plate shall be:

(i) The thickness of the connecting plate for plate 5mm or less in thickness.*

(ii) 1mm less than the thickness of plate for plate 6mm or more in thickness, unless the weld is designated on the detail drawing to be built out to obtain full throat thickness.*

Effective Dimensions of Fillet Welds

Refer to Clause 4.3.3, CSA W59.2 and to Figure 2.

Groove Welds

Complete Joint Penetration Groove Welds

A complete joint penetration groove weld is defined as one made from one side on a backing or on both sides combined with back gouging to provide complete joint penetration and fusion of weld and base metal throughout the depth of the joint. Refer to Figure 3.*

Partial Joint Penetration - Minimum Depth of Bevel

The minimum groove depth of partial joint penetration groove welds shall be as shown in Table 2 for single or double partial joint penetration groove welds. The effective throat may be measured as described in Clause 4.2.3.3. and 4.3.3.4. of W59.2 and as detailed in Table 3.

Acceptable and Defective Profiles

Refer to Figure 4.

Shop Standards

(a) Splicing
(b) Preparation of Material
(c) Assembly Practices
(d) Allowable Workmanship Tolerances from Detailed Drawings
(e) Control of Distortion
(f) Weld Terminations
(g) Quality of Welds
(h) Welding Inspection
(i) Repair Work

(a) Splicing

Shop splices in each component of a long built-up member shall be made before the component is incorporated into the complete member. *

Filler plates may be used in the splicing of parts of different thickness; or in connections where, due to existing geometric alignment, offsets must be accommodated to permit single framing* (see Clauses 4.4.2 & 4.4.3, W59.2).

Details for the use of filler plates will be supplied by the designer.

(b) Preparation of Material

Edge preparation shall be accomplished by disc grinding, shearing, plasma-arc cutting, sawing, chipping, planing, milling, routing or other method approved by the engineer.*

When disc grinding is used for edge preparation, high speed flexible grinding discs shall be used. The grinding disc shall be suitable for aluminium and be maintained free of lubricants and other foreign material.*

When shearing is used for edge preparation, the shear blade shall be kept sharp and free of foreign material. The sheared edge of aluminium shall be filed, planed or routed to remove any metal that can possibly entrap foreign material such as cutting oil.*

To allow effective cleaning surfaces and edges to be welded shall be smooth, uniform, and free from fins, cracks, and other defects that could introduce porosity or oxides into the weld.*

When plasma arc cutting is used for the edge preparation of heat-treatable alloys, 3mm of material shall be removed from the cut edges by mechanical means. This includes both butt and T-joints. Note, plasma arc cutting of heat treatable aluminium alloys may produce lamellar fissures.*

In plasma arc cutting of non heat-treatable alloys, the arc shall be adjusted and directed to avoid cutting beyond the prescribed lines. Surface roughness of the cut surfaces shall be no greater than 25μm for material up to 100mm thick and 50μm for material 100-200mm thick, except that the ends of members not subject to calculated stress at the ends may meet the surface roughness value of 50μm. Roughness exceeding the permissible amount and occasional notches or gouges greater than 5mm deep on otherwise satisfactory surfaces shall be flared into the cut surface by machining or grinding to a slope not exceeding 1 in 10.*

At cut edges, occasional notches or gouges less than 10mm deep in material up to 100mm thick, or less than 15mm deep in material thicker than 100mm may, with the engineer's approval be repaired by welding.*

The removal of temporary welds or of unacceptable work and the back gouging of welds may be effected by machining, sawing, air carbon arc, plasma arc, or impact chipping.*

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.*

Re-entrant corners shall have a radius of not less than 10mm. The corner radius and its adjacent cuts shall meet without offset and without cutting past the point of tangency.*

Note: *Equipment used for preparing aluminium should be used solely for this purpose to prevent contamination of the base material from foreign materials.*

(c) Assembly Practices

Corner and T-joints shall be brought into contact as closely as is practicable. The separation between parts shall, in general, not exceed 2mm. If the separation is greater than 2mm, the legs of fillet welds shall be increased by the amount of the separation, or the contractor shall demonstrate that the required effective throat has been obtained. Separations up to 8mm may be welded using backing material where required.*

Backing material shall be of ceramic, glass tape, austenitic stainless steel, or an aluminium alloy of the same group number as the base metal (see Table 5). The backing shall be in contact with the root side of the components being welded. If aluminium backing is to be left permanently in place, it may be attached by continuous or intermittent fillet welds.*

Whenever practicable, the work shall be positioned so that groove welds are made in the flat position and fillet welds are made in the flat or horizontal position.*

Separation between faying surfaces of lap joints and of the backing in butt joints shall not exceed 2mm. The use of filler plates to correct poor fit is prohibited except as approved by the engineer* and made in accordance with Clause 4.4 of CSA W59.2.

Abutting parts to be joined by groove welds shall be properly aligned. An offset in alignment not exceeding one-tenth of the thickness of the thinner part, but in no case more than 3mm, may be allowed as a departure from the specified alignment. In correcting misalignment in such cases, the parts shall not be drawn in to a slope greater than 1:25. Measurement of offset shall be based on the mid planes of the parts, unless otherwise specified on the drawings.*

Parts to be joined shall be brought into correct alignment or required preset and held in position by such means as fixtures, strongbacks, clamps or guy lines, or tack welds until the welding has been completed. The use of fixtures is recommended when practicable since they can bring the parts into line along the total length. The fixtures or tack welds shall be adequate to resist the forces developed during welding.*

Tack welds shall be made by a qualified welder in accordance with an approved welding procedure, and shall be subject to the same quality requirements as the final welds. Tack welds which are to be incorporated into the final weld shall be made with filler metal of the same composition, and shall be cleaned thoroughly before incorporation. Tack welds not incorporated into final welds shall be removed by mechanical means.*

Temporary welds shall be made by a qualified welder in accordance with an approved welding procedure. Strongbacks, clips, hangers, and other temporary parts that have been welded in place to facilitate assembly shall be removed to give a smooth metal surface, free of defects.*

(d) Allowable Workmanship Tolerances From Detailed Drawings

Tolerances shall be detailed on the individual welding procedure data sheets.

Suggested guidelines of workmanship tolerances are as follows:

1)	Root face	± 1/16" (1.6mm)
2)	Root Opening of Joint with backing	+ 1/4" (6.4mm) - 1/16" (1.6mm)
3)	Root Opening of Joints without backing	± 1/16" (1.6mm)
4)	Groove angle of joint	+ 10° - 5°

(e) Control Of Distortion And Shrinkage Stresses

In assembling and joining parts of a structure or a built-up member, and in welding reinforcing parts to a member, the procedure and sequence shall be such as to minimize distortion and shrinkage.*

Insofar as is practicable, all welds shall be deposited in a sequence that will balance the applied heat of welding while the welding progresses.*

Before the start of welding on a member in which shrinkage or distortion is likely to affect the adequacy of the member or structure, the contractor shall prepare a welding sequence for approval by the engineer, if requested.*

The direction of general progression in welding on members shall be from points where the parts are relatively fixed in position with respect to each other toward points where they have greater relative freedom of movement.*

Joint expected to have larger shrinkage shall normally be welded before joints expected to have lesser shrinkage and with as little restraint as possible.

In making welding under conditions of severe shrinkage restraint, the welding shall be carried continuously to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum specified preheat and interpass temperature.

(f) Weld Terminations

Welds shall be started and stopped in a manner that ensures sound welds.*

If extension bars or run-on and run-off plates are used, they shall be of the same alloy group as the base metal (see Table 5), and shall be removed upon completion and cooling of the weld. The ends of the weld shall be made smooth and flush with the edges of the adjacent parts.*

When it is impossible to terminate a weld on an extension bar or run-off plate, consideration should be given to terminating the weld in a low stress area.*

The techniques for terminating a fillet weld, or a cover pass bead, within a joint include:

(a) reversing the direction of travel for a distance sufficient to create a smooth transition;

(b) increasing travel speed to reduce crater size;

(c) providing suitable build-up, and dressing the crater area flush with the weld surface by mechanical means.*

Crater defects in weld beads, that are intended to be incorporated into final welds, shall be removed by mechanical means prior to additional welding.*

(g) Quality Of Welds

(i) Weld Profiles-

- Insufficient throat is not permitted. *
- Welds shall be free from overlap. *
- Continuous undercut depth shall not exceed the smaller of t/5 or 1mm on each side of the joint, where t is the member thickness. Isolated undercut shall not exceed 2mm in depth, nor shall the length of undercut greater than 1mm in depth exceed 15mm. The intervals between such isolated cases of undercut shall exceed 100mm.*

Groove Welds-

- Reinforcement at the centre of the weld in butt and corner joints shall not exceed the values given in Figure 4 (a) and (b) and, if present, shall be built up uniformly to blend smoothly into the surface of the base metal to a maximum at the centre of the weld.*
- The ends of butt joints shall be of sound metal and maintain the profile of the welded joint.*
- Groove welds shall be free of the defects shown for butt joints in Figure 4(c).*

Fillet Welds-

- The faces of fillet welds shall be in accordance with Figure 1 (a).*

- Fillet welds in any single continuous weld shall be permitted to underrun the nominal size required by 1.5mm without correction, provided that the undersize weld does not exceed 10% of the length of the welds and does not occur at the ends of web-to-flange welds in girders for a length equal to twice the width of the flange.*

- Fillet welds shall be free of the defects shown for fillet weld profiles in Figure 1 (b).*

(ii) Surface Defects-

- Surface cracks in the weld shall not be permitted.*

- Lack of fusion shall not be permitted.*

- Weld termination craters shall not be permitted (see Part F).*

- If surface finishing reveals porosity then the section shall be inspected for internal porosity (see Clause (iii)).*

(iii) Internal Defects-

- Cracks shall not be permitted.*

- Dispersed porosity shall not exceed the limits specified in Figure 12. For linear porosity or similar indications, Table 8 shall apply. (Ref. to CSA W59.2).*

- Individual discontinuities such as porosity, lack of fusion and incomplete penetration shall not exceed the limits specified in Table 8. (Ref. to CSA W59.2).*

(h) Welding Inspection

(i) Visual Inspection-

- The extent of visual inspection by the inspector shall be as stipulated in the contract.*

- A visual inspection procedure and an outline of inspection points shall be prepared by the inspection organization.*

- Inspection shall include material, consumables, surface preparation, fit-up, and welding practices including pre- or post-heat treatment, weld profile, and geometry.*

- Surfaces to be inspected shall be free of any extraneous material or substance which might interfere with interpretation.*

- Welded joints shall be visually inspected to check for the presence of surface discontinuities as given in Clause (g).*

(ii) Non Destructive Testing-

- When nondestructive testing is required as part of the contract, in addition to the visual inspection required in this Standard, it shall be so stated in the information furnished to the bidders. This information shall designate the welds to be examined and the extent of examination of each weld and the method of testing.*

- For detecting discontinuities that are open to the surface, liquid penetrant inspection by the methods set forth in ASTM Standard E165 may be used. Procedures and acceptance criteria shall be in accordance with Clause 7.5 of CSA W59.2.*

- When radiographic inspection is required, the procedures, techniques, and acceptance criteria shall be in accordance with Clause 7.6 of CSA W59.2.*

- When ultrasonic testing is used agreement as to the procedures and acceptance criteria shall be in accordance with Clause 7.7. of CSA W59.2.*

(j) Repair Work

(i) Repair of Defects-

- All welding repairs shall be made by suitably preparing the site of the defect, followed by welding and, if required, finishing the weld flush with the adjacent surface (see Clause 5.12 of CSA W59.2) to satisfy the requirements of Clause (g).*

(ii) Correction of Distortion-

- Members distorted by welding, and requiring rectification shall be straightened at ambient temperature by mechanical means, or by a combination of mechanical means and a controlled amount of localized heat.*

- If localized heating is to be applied in any straightening operation, the complete procedure shall be filed with, and approved by, the engineer. Maximum holding times at various temperatures for aluminium alloys prior to correction of distortion shall be in accordance with Table 7 of CSA W59.2*

**TABLE 1

Specified Minimum Tensile Strengths for Welded Aluminium Alloy (With No Postweld Heat Treatment)

	MINIMUM UTS		MINIMUM YS*	
ALLOY	MPa	(KSI)	MPa	(KSI)
1050	60	(8.7)	20	(2.9)
1060	60	(8.7)	20	(2.9)
1100	80	(11.6)	25	(3.6)
1350	60	(8.7)	20	(2.9)
3003	100	(14.5)	35	(5.1)
3004	150	(21.8)	60	(8.7)
5005	110	(16.0)	40	(5.8)
5052	170	(24.7)	70	(10.2)
5083	260	(37.7)	125	(18.1)
5086	235	(34.1)	105	(15.2)
5154	200	(29.0)	90	(13.1)
5254	200	(29.0)	90	(13.1)
5454	205	(29.7)	90	(13.1)
5456	280	(40.6)	135	(19.6)
6005	170	(24.7)	100	(14.5)
6061	170	(24.7)	110	(16.0)
6063	120	(17.4)	70	(10.2)
6101	130	(18.9)	80	(11.6)
6351	170	(24.7)	110	(16.0)
7004	275	(39.9)	165	(23.9)
7005	275	(39.9)	165	(23.9)

** 0.2% offset in 50mm gauge length*
UTS = ultimate tensile strength
YS = yield strength

* TABLE 1 (CONTINUED)

FILLER ALLOY SELECTION GUIDE

	FILLER ALLOYS															
ASE METAL ALLOYS	413.0, 443.0 A444.0, 356.0 A356.0, A357.0 A359.0	7004 7005,7046 7146,710.0 712.0	6061,6063 6101,6151 6201,6351 6951	5456	5454	5254 5652	5154	5086	5083	5052	5005 5050	3004 ALC 3004	1100 3003 ALC 3003	2219	1060 1350
060,1350	4043	4043	4043	5356	5356	5654	5356	5656	5356	4043	4043	4043	1100	2319	1100
219 100,3003 LCLAD 3003	4145 4043	4145 4043	2319 4043	- 5356	- 5356	- 5654	- 5356	- 5356	- 5356	- 5356	- 4043	2319 4043	2319 1100	2319	
004, ALCLAD 3004	4043		4043	5356	5356	5654	5356	5356	5356	5356	4043	4043			
005,5050	4043	5356	4043	5356	5356	5654	5356	5356	5356	5356	4043				
052	4043	5356	5356	5356	5356	5654	5356	5356	5356	5356					
083	-	5356	5356	5356	5356	5654	5356	5356	5356						
086	-	5356	5356	5356	5356	5654	5356	5356							
154	-	5356	5356	5356	5356	5654	5356								
254,5652	-	5356	5654	5654	5654	5654									
454	-	5654	5356	5356	5554										
456	-	5556	5356	5556											
061,6063,6101 151,6201 351,6951	4043	5256	4043												
004,7005,7046 146,710.0,712.0	4043	5356													
13.0,443.0 444.0 56.0,A356.0 57.0,359.0	4043														

(Continued)

TABLE 1 (CONCLUDED)

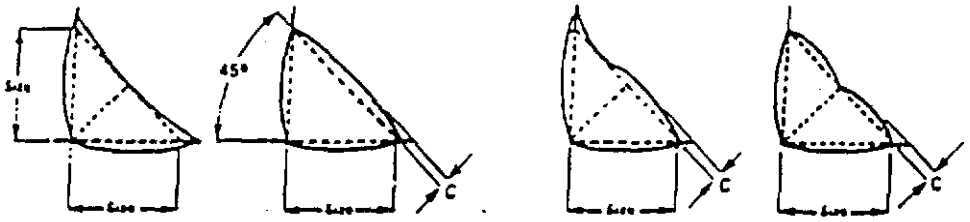
OTES:

1) *Filler alloys 5XXX may be substituted for each other and for filler alloy 4043 in the welding of 3XXX, 5XXX,and 6XXX alloys to modify corrosion resistance, weld metal mechanical properties and for colour match on anodizing. Neither filler alloy 4043 nor 4047 should be used to join 5XXX alloys with Mg levels in excess of 2.5% as excessive formation of $Mg_x Si_y$ lowers weld metal ductility.*

2) *Of the 5XXX series, only filler alloy 5554 is suitable for elevated temperature service (65°C).*

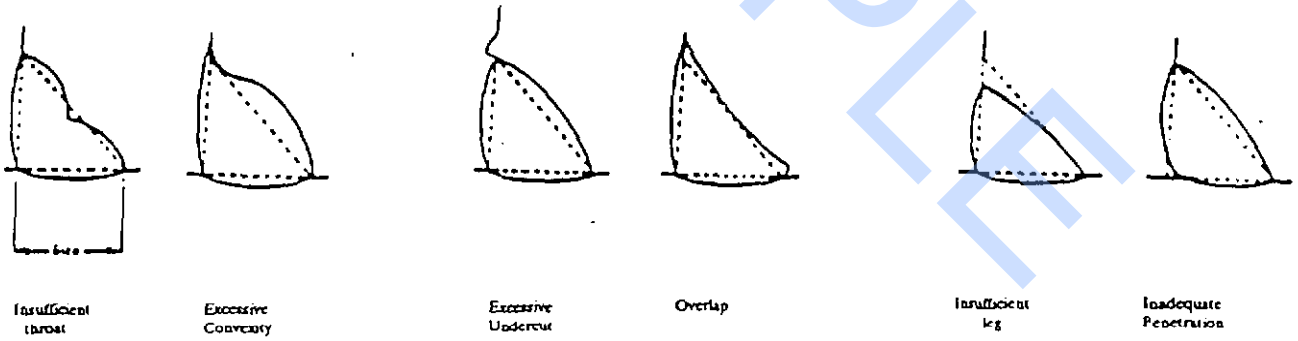
3) *Filler alloy 4043 may be used to join alloys 1XXX and 3XXX for ease of welding on electrical connections, but not for corrosion resistance colour match applications.*

4) *Filler alloy 4047 may be substituted for filler alloy 4043 for joining castings to alloy 1XXX and 3XXX. Filler alloy 4047 has high hot cracking resistance for these applications.*



The convexity shall not exceed: C = 0.1s + 1.5 where s = size in mm

(a) Acceptable Fillet Weld Profiles



(b) Unacceptable Fillet Weld Profiles

* Figure 1
Fillet Weld Profiles

The required size, S, of a fillet weld (see Figure 2) to give an effective throat, E, shall be given by:

$S = 2E \sin(\theta/2) + G$

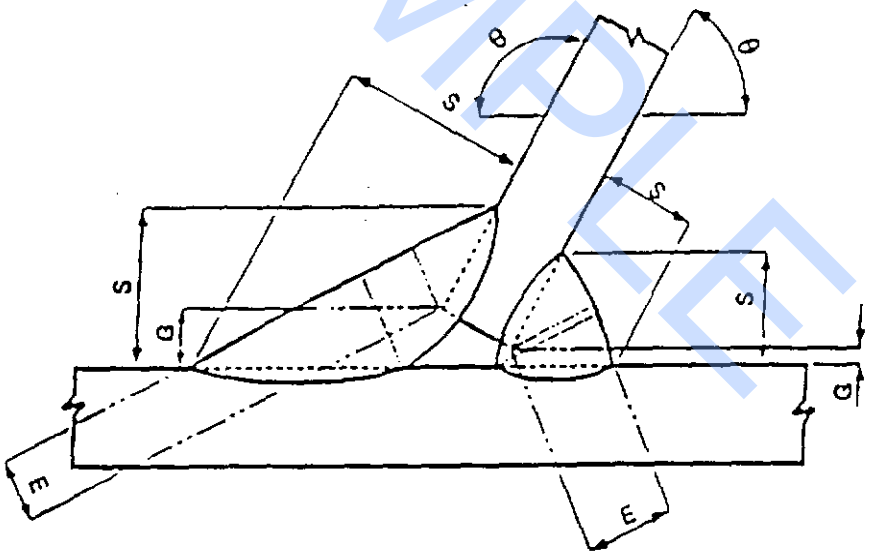
where
G = gap, mm

θ = angle between fusion faces

The gap shall not exceed 5mm, but gaps less than 1mm may be neglected.

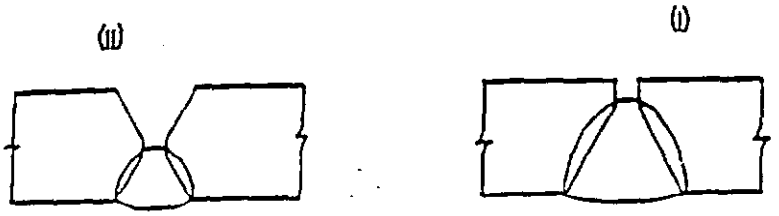
* FIGURE 2

EFFECTIVE THROAT OF FILLET WELDS

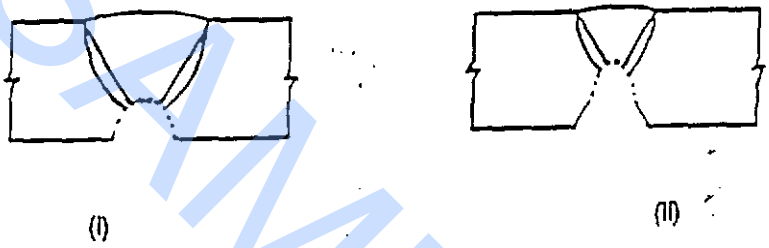


*** Figure 3

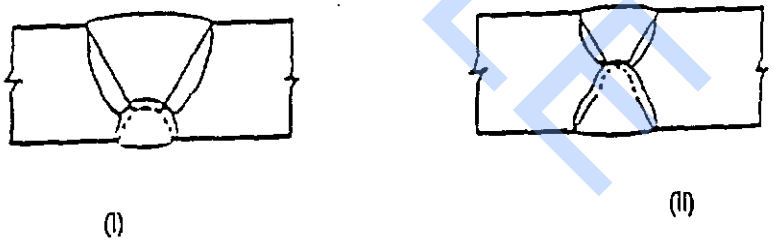
COMPLETE JOINT PENETRATION GROOVE WELDS



(a) First Side Welded

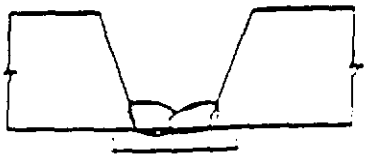


(b) Back of first pass gouged to Sound Metal



(c) Second Side Welded

Preparation. Gouging and Welding of Butt Joints from both sides.



Welding of Butt Joints from one side on Backing

*** TABLE 2**

GROOVE DEPTH OF PARTIAL JOINT PENETRATION GROOVE WELDS

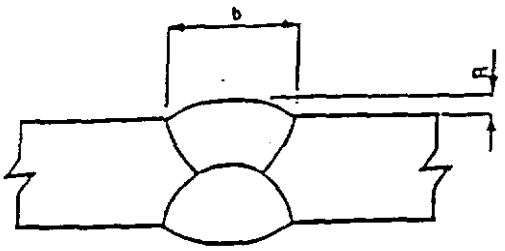
WELD METHOD	GROOVE TYPE	GROOVE ANGLE, O	WELD POSITION	MINIMUM GROOVE DEPTH
GMAW GTAW PAW	J-,U- --- V-bevel	- --- $0 \geq 60°$	all positions	effective throat
GMAW	V-bevel	$45° \leq O < 60°$	Flat, vertical	
GTAW PAW	V-bevel	$45° \leq 0 < 60°$	all positions	effective throat plus 3mm
GMAW	V-bevel	$45° \leq 0 < 60°$	horizontal overhead	

*** TABLE 3**

EFFECTIVE THROAT OF PARTIAL JOINT PENETRATION GROOVE WELDS

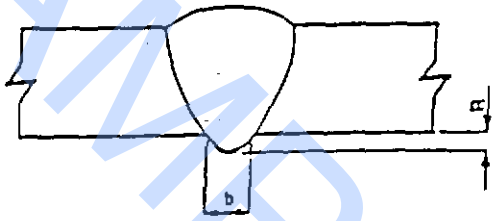
BASE METAL THICKNESS OF THICKER PART JOINED, MM	MINIMUM EFFECTIVE THROAT, MM
3 to 5	2*
Over 5 to 6	3*
Over 6 to 13	5
Over 13 to 20	6
Over 20 to 40	8
Over 40 to 60	10
Over 60 to 150	13
Over 150	16

* *Minimum size for dynamically loaded structures shall be the lesser of plate thickness or 5mm.*



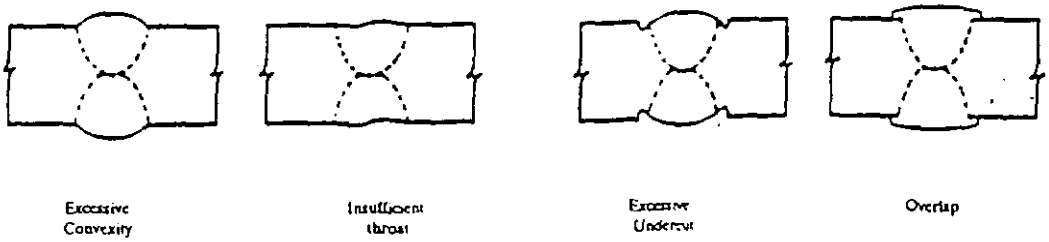
R = convexity
b = weld width
For statically loaded structures R ≤ 1.5 + 0.2b
For dynamically loaded structures R ≤ 1.5 + 0.15b

(a) Acceptable Groove Weld Profiles in Butt Joint Welded from Both Sides



R = convexity
b = weld width
For statically loaded structures R ≤ (1 + 1.2b) ≤ 5
For dynamically loaded structures R ≤ (1 + 0.6b) ≤ 4

(b) Acceptable Groove Weld Profiles in Butt Joint Welded from One Side



(c) Unacceptable Groove Weld Profiles in Butt Joints

* FIGURE 4

GROOVE WELD PROFILES

* TABLE 5

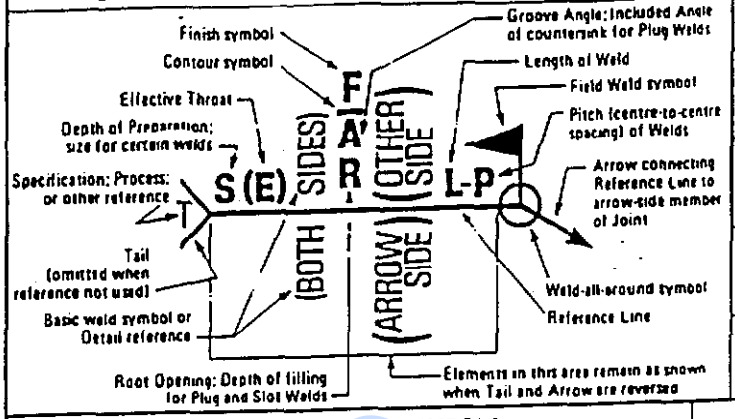
BASE METAL ALLOY GROUPINGS

		NOMINAL COMPOSITION, MASS %								
GROUP	ALLOY	Cu	Mn	Si	Mg	Zn	Cr	Ti	Zr	Al
1	1050	-	-	-	-	-	-	-	-	99.50 min
	1060	-	-	-	-	-	-	-	-	99.60 min
	1100	0.12	-	-	-	-	-	-	-	99.00 min
	11350	-	-	-	-	-	-	-	-	99.50 min
	3003	0.12	1.2	-	-	-	-	-	-	Remainder
2	3004	-	1.2	-	1.0	-	-	-	-	Remainder
	5005	-	-	-	0.8	-	-	-	-	Remainder
	5052	-	-	-	2.5	-	0.25	-	-	Remainder
	5154	-	-	-	3.5	-	0.25	-	-	Remainder
	5254	-	-	-	3.5	-	0.25	-	-	Remainder
	5454	-	0.8	-	2.7	-	0.12	-	-	Remainder
3	5083	-	0.7	-	4.4	-	0.15	-	-	Remainder
	5086	-	0.45	-	4.0	-	0.15	-	-	Remainder
	5456	-	0.8	-	5.1	-	0.12	-	-	Remainder
4	6061	0.28	-	0.6	1.0	-	0.20	-	-	Remainder
	6063	-	-	0.4	0.7	-	-	-	-	Remainder
	6101	-	-	0.5	0.6	-	-	-	-	Remainder
	6351	-	0.6	1.0	0.6	-	-	-	-	Remainder
5	7004	-	0.45	-	1.5	4.2	-	-	0.15	Remainder
	7005	-	0.45	-	1.4	4.5	0.13	0.04	0.14	Remainder

* FILLER METAL ALLOY GROUPINGS

		NOMINAL COMPOSITION, MASS %						
GROUP	ALLOY	Cu	Mn	Si	Mg	Cr	Ti	Al
1	5183	-	0.8	-	4.8	0.15	-	Remainder
	5356	-	0.12	-	5.0	0.12	0.13	Remainder
	5554	-	0.8	-	2.7	0.12	0.12	Remainder
	5556	-	0.8	-	5.1	0.12	0.12	Remainder
	5654	-	-	-	3.5	0.25	0.10	Remainder
2	4043	-	-	5.2	-	-	-	Remainder
	4047	-	-	12.0	-	-	-	Remainder
	4145	4.0	-	10.0	-	-	-	Remainder
3	1100	0.12	-	-	-	-	-	99.0% min

LOCATION OF ELEMENTS OF A WELDING SYMBOL



BASIC WELDING SYMBOLS and THEIR LOCATION SIGNIFICANCE

Location Significance	Fillet	Plug or Slot	Back or Backing	Stud	Arc Spot
ARROW SIDE			Groove Weld Symbol		
OTHER SIDE			Groove Weld Symbol	Not Used	
BOTH SIDES		Not Used	Not Used	Not Used	Not Used
No Arrow Side or Other Side Significance	Not Used	Not Used	Not Used	Not Used	Not Used

SUPPLEMENTARY SYMBOLS

Weld All-Around	Field Weld	Melt-Thru	BACKING, SPACER, OR CONSUMABLE INSERT	CONTOUR: Flush	CONTOUR: Convex	CONTOUR: Concave

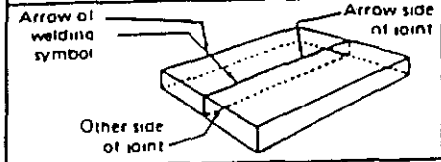
Where process abbreviations are to be included in the tail of the welding symbol, reference is made to Table A, Designation of Welding and Allied Processes by Letters, of AWS 2.4-79

11 FLUSH CONTOUR SYMBOL

Flush contour symbol indicates face of weld to be made approximately flush.

When used without a surface finish symbol, it indicates weld without subsequent finishing

1 BASIC JOINTS BUTT JOINT



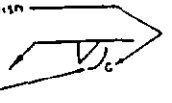
6 WELD-ALL-AROUND SYMBOL

Weld-all-around symbol indicates that weld extends completely around the joint

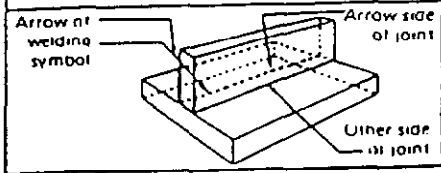
12 CONVEX CONTOUR SYMBOL

Finish symbol (user's standard) indicates method of obtaining specified contour but not degree of finish

Convex contour symbol indicates face of weld to be finished to convex contour by grinding



2 BASIC JOINTS T-JOINT



7 FIELD WELD SYMBOL

Field weld symbol indicates that weld is to be made at a place other than that of initial construction

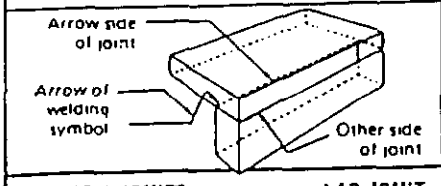
Flag points away from the arrow (WSB recommendation)

13 COMPLETE JOINT PENETRATION

Indicates complete joint penetration groove weld regardless of type of weld and joint preparation

To be used on design drawing only (see Clause 4.1.1.1.4)

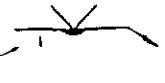
3 BASIC JOINTS CORNER JOINT



8 MELT-THRU SYMBOL

Any applicable weld symbol

Size (height)
– Omission indicates no special height desired



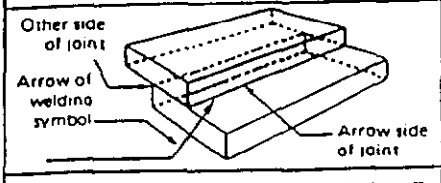
14 MULTIPLE REFERENCE LINES

First operation shown on reference line nearest arrow

Second operation, or supplementary data

Third operation, or test information

4 BASIC JOINTS LAP JOINT



9 JOINT WITH BACKING

With groove-weld symbol

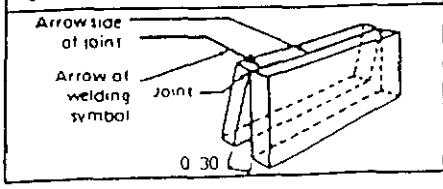
NOTES
– Material (M) and dimensions of backing as specified.
– "R" indicates backing removed after welding.
– See Clause D1.6

15 FINISHING OF WELDS

Finishing of welds other than cleaning is indicated by suitable contour and finish symbols. The following finishing symbols indicate the method, not the degree, of finish:

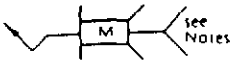
C – Chipping
G – Grinding
M – Machining
R – Rolling
H – Hammering

5 BASIC JOINTS EDGE JOINT



10 JOINT WITH SPACER

With modified groove-weld symbol



NOTES
– Material (M) and dimensions of spacer as specified
– See Clause D1.6

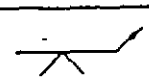
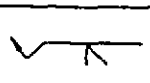
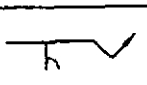
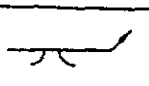
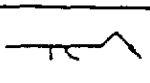
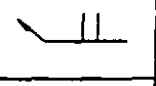
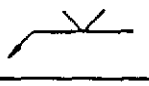
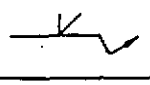
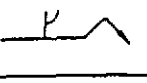
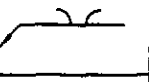
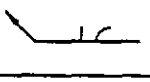
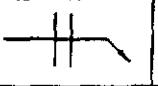
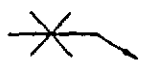
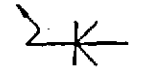
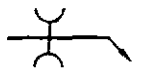
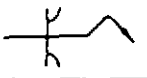
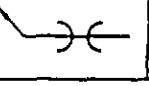
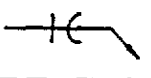
Double-bevel symbol

16 ABBREVIATIONS

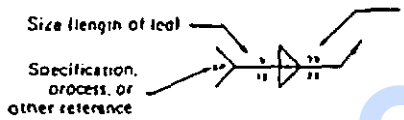
GTSM;– Gouge To Sound Metal
CP – Complete Penetration
PP – Partial Penetration

Extracted from W59.2-M1991

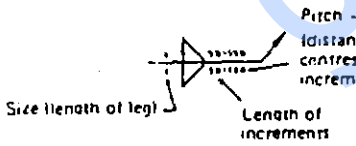
BASIC WELDING SYMBOLS AND THEIR LOCATION SIGNIFICANCE

Square Groove	V-Groove	Bevel-Groove	U-Groove	J-Groove	Flare-V-Groove	Flare-Bevel-Groove	Location Significance
							ARROW SIDE
							OTHER SIDE
							BOTH SIDES

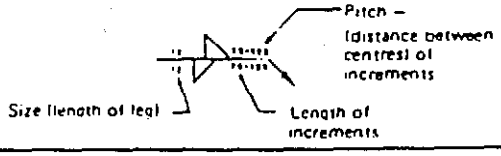
17 DOUBLE-FILLET WELDING SYMBOL



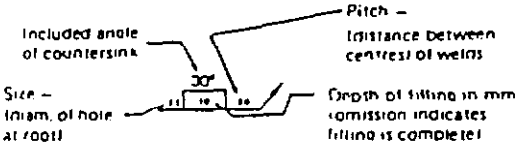
18 CHAIN INTERMITTENT FILLET WELDING SYMBOL



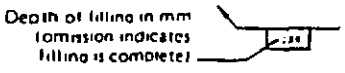
19 STAGGERED INTERMITTENT FILLET WELDING SYMBOL



20 PLUG WELDING SYMBOL

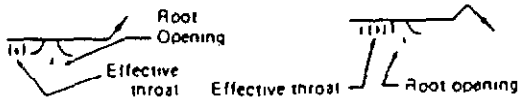


21 SLOT WELDING SYMBOL



Orientation, location, and all dimensions other than depth of filling as shown on the drawing

22 FLARE-V AND FLARE-BEVEL-GROOVE WELDING SYMBOLS

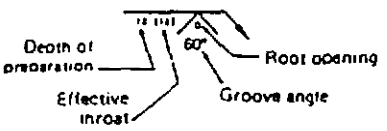


23 SQUARE-GROOVE WELDING SYMBOL

For square groove the depth of preparation is omitted in the symbol

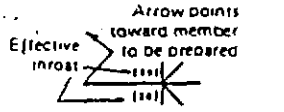
Omission of effective throat without designating the weld as "seal weld" in the tail of the symbol indicates complete joint penetration is required

24 SINGLE-V-GROOVE WELDING SYMBOL



Omission of depth preparation and effective throat indicates complete joint penetration is required.

25 DOUBLE-BEVEL-GROOVE WELDING SYMBOL



Omission of depth of preparation and effective throat indicates total depth of preparation — symmetrical in case of double-groove welds — equal to the thickness of the member and, hence, complete joint penetration groove weld is required

26 WELDING SYMBOL FOR GROOVES WELDED FROM BOTH SIDES WITH BACKGOUGING

Only depth of preparation is required in the welding symbol

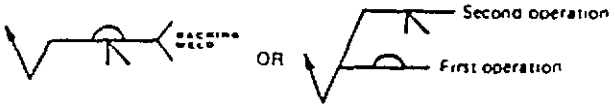
GTSM signifies total effective throat is equal to the thickness of material. See Clause D1.2 of Appendix D.

27 BACK-WELDING SYMBOLS

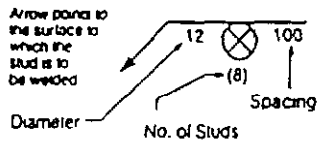
Any single-groove weld with a pass from the Other side with no special identification in the tail is considered a groove weld with a back weld

28 BACKING WELDING SYMBOLS

Any single-groove weld with a pass from one side identified in the tail by "backing weld" is considered to be a groove weld with a backing weld.

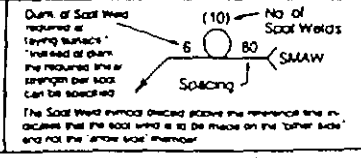


29 STUD WELDING SYMBOL



NOTES:
(1) - Stud Weld symbol is always below the reference line
(2) - the location of the first and last Stud Weld in each single line shall be specified on the drawing

30 ARC SPOT WELDING SYMBOL



NOTES:
(1) - Arc Spot Weld symbols can be placed above or below the reference line, depending on whether welding is to be done on the "other side" or the "arrow side" member respectively
(2) - The location of the first and last arc spot weld in each single line shall be specified on the drawing

Extracted from W59.2-M1991

BIBLIOGRAPHY

Those items marked with an asterisk have been extracted in whole or in part from:

CSA W59.2-M1991 WELDED ALUMINIUM CONSTRUCTION, CANADIAN STANDARDS ASSOCIATION, 1991, REXDALE, ONTARIO, CANADA.

Those items marked with a double asterisk have been extracted in whole or in part from:

CSA W47.2-M1987 CERTIFICATION OF COMPANIES FOR FUSION WELDING OF ALUMINIUM,
CANADIAN STANDARDS ASSOCIATION, 1987, REXDALE, ONTARIO, CANADA.

Those items marked with a triple asterisk have been extracted in whole or in part from:

CSA W59-M1989 WELDED STEEL CONSTRUCTION (METAL ARC WELDING),
CANADIAN STANDARDS ASSOCIATION, 1989, REXDALE, ONTARIO, CANADA.

COMPANY NAME: _____

COMPANY ADDRESS: _____

W47.2/W59.2

WELDING ENGINEERING STANDARDS
W.E.S. & GENERAL SPECIFICATION

General Notes

This Welding Engineering Standard is prepared in accordance with CSA W47.2-1987.

All welding shall be performed in accordance with the requirements of CSA W47.2-1987 and conditions laid down in CSA Standard W59.2-1991 or latest revisions to the above mentioned Standards.

All welders and welding operators shall be qualified in accordance with CSA W47.2. They shall be allowed to weld only in the level (I, II or III), category (F, H, V, O), process and electrode group for which they are qualified.

Any welding fabrication sub-contracted by this Company shall be sublet only to companies certified by the Canadian Welding Bureau under CSA W47.2. The subcontractor's CWB approved procedures may be used if satisfactory to the prime fabricator, otherwise the fabricator may provide the approved procedures for use on pertinent sub-contracted work.

Changes or revisions in welding standards shall be submitted to the Bureau for approval in accordance with Clause 3.6 of CSA Standard W47.2.

Only welding consumables certified by the Canadian Welding Bureau to AWS A5.10 shall be used. Each welding Procedure Data Sheet will designate the filler alloy to be used for the joint, the applicable codes and the number of the Welding Procedure Specification which governs the Data Sheet applications.

Aluminium base metal to be welded by this firm shall conform to the requirements of Clause 3.5 of CSA W59.2. Refer to Table 1 for allowable base metals and matching filler alloys.

	X
CWB	ENGINEER OR SUPERVISOR

X *This space to be stamped by P. Eng. if Div. 1 or Div. 2 company.*
Welding Supervisor's Signature if Div. 3 company.

Unless called for otherwise on a specific Data Sheet, vertical welds shall be made with the progression of each pass in an upward direction. If welds are to be made in a vertical down sequence, the operator and procedure shall be qualified on a separate basis.

All surfaces to be welded shall be free from water stain, excessive aluminium oxide, paint, grease cutting fluids and moisture or any other material that may cause porosity, or adversely affect the quality of welds.*

All surfaces to be welded, after having been cleaned of oil and grease, shall be scratch-brushed before welding to remove excessive oxide. In multi pass welds the weld bead and adjacent area shall be scratch-brushed between passes. A hand or power-driven stainless steel wire brush shall be used. The brushes shall be kept exclusively for use with Aluminium and be kept clean and free from contaminants.*

Welding shall not be done when the adjacent metal temperature within a distance not less than the metal thickness or 75mm is lower than 0°C. Maximum temperatures shall not exceed those specified in Clause 5.14* of W59.2.

The operator and the work shall be adequately protected against the direct effect of wind, rain and snow.*

Welding shall not be done when the work surfaces are damp.*

NOTE: Information pertaining to the following items shall be detailed on the welding procedure data sheets submitted to the CWB for approval:

1) *Profile of typical joint to be welded*
2) *Type of joint (i.e. butt, corner, tee, etc.)*
3) *Type of weld*
4) *Preparation and fit-up*
5) *Weld Symbol*
6) *Thickness range.*

Fillet Welds

Acceptable and Defective Profiles

Refer to Figure 1.

Minimum and Maximum Fillet Sizes Permissible

The minimum fillet size shall be given by the least of

t or (t/5 + 3), or 6mm

where

t = the thickness of the thicker material, mm *

The maximum fillet size permitted along the edge of a plate shall be:

(i) The thickness of the connecting plate for plate 5mm or less in thickness.*

(ii) 1mm less than the thickness of plate for plate 6mm or more in thickness, unless the weld is designated on the detail drawing to be built out to obtain full throat thickness.*

Effective Dimensions of Fillet Welds

Refer to Clause 4.3.3, CSA W59.2 and to Figure 2.

Groove Welds

Complete Joint Penetration Groove Welds

A complete joint penetration groove weld is defined as one made from one side on a backing or on both sides combined with back gouging to provide complete joint penetration and fusion of weld and base metal throughout the depth of the joint. Refer to Figure 3.*

Partial Joint Penetration - Minimum Depth of Bevel

The minimum groove depth of partial joint penetration groove welds shall be as shown in Table 2 for single or double partial joint penetration groove welds. The effective throat may be measured as described in Clause 4.2.3.3. and 4.3.3.4. of W59.2 and as detailed in Table 3.

Acceptable and Defective Profiles

Refer to Figure 4.

Shop Standards

(a) Splicing
(b) Preparation of Material
(c) Assembly Practices
(d) Allowable Workmanship Tolerances from Detailed Drawings
(e) Control of Distortion
(f) Weld Terminations
(g) Quality of Welds
(h) Welding Inspection
(i) Repair Work

(a) Splicing

Shop splices in each component of a long built-up member shall be made before the component is incorporated into the complete member. *

Filler plates may be used in the splicing of parts of different thickness; or in connections where, due to existing geometric alignment, offsets must be accommodated to permit single framing* (see Clauses 4.4.2 & 4.4.3, W59.2).

Details for the use of filler plates will be supplied by the designer.

(b) Preparation of Material

Edge preparation shall be accomplished by disc grinding, shearing, plasma-arc cutting, sawing, chipping, planing, milling, routing or other method approved by the engineer.*

When disc grinding is used for edge preparation, high speed flexible grinding discs shall be used. The grinding disc shall be suitable for aluminium and be maintained free of lubricants and other foreign material.*

When shearing is used for edge preparation, the shear blade shall be kept sharp and free of foreign material. The sheared edge of aluminium shall be filed, planed or routed to remove any metal that can possibly entrap foreign material such as cutting oil.*

To allow effective cleaning surfaces and edges to be welded shall be smooth, uniform, and free from fins, cracks, and other defects that could introduce porosity or oxides into the weld.*

When plasma arc cutting is used for the edge preparation of heat-treatable alloys, 3mm of material shall be removed from the cut edges by mechanical means. This includes both butt and T-joints. Note, plasma arc cutting of heat treatable aluminium alloys may produce lamellar fissures.*

In plasma arc cutting of non heat-treatable alloys, the arc shall be adjusted and directed to avoid cutting beyond the prescribed lines. Surface roughness of the cut surfaces shall be no greater than 25μm for material up to 100mm thick and 50μm for material 100-200mm thick, except that the ends of members not subject to calculated stress at the ends may meet the surface roughness value of 50μm. Roughness exceeding the permissible amount and occasional notches or gouges greater than 5mm deep on otherwise satisfactory surfaces shall be flared into the cut surface by machining or grinding to a slope not exceeding 1 in 10.*

At cut edges, occasional notches or gouges less than 10mm deep in material up to 100mm thick, or less than 15mm deep in material thicker than 100mm may, with the engineer's approval be repaired by welding.*

The removal of temporary welds or of unacceptable work and the back gouging of welds may be effected by machining, sawing, air carbon arc, plasma arc, or impact chipping.*

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.*

Re-entrant corners shall have a radius of not less than 10mm. The corner radius and its adjacent cuts shall meet without offset and without cutting past the point of tangency.*

Note: *Equipment used for preparing aluminium should be used solely for this purpose to prevent contamination of the base material from foreign materials.*

(c) Assembly Practices

Corner and T-joints shall be brought into contact as closely as is practicable. The separation between parts shall, in general, not exceed 2mm. If the separation is greater than 2mm, the legs of fillet welds shall be increased by the amount of the separation, or the contractor shall demonstrate that the required effective throat has been obtained. Separations up to 8mm may be welded using backing material where required.*

Backing material shall be of ceramic, glass tape, austenitic stainless steel, or an aluminium alloy of the same group number as the base metal (see Table 5). The backing shall be in contact with the root side of the components being welded. If aluminium backing is to be left permanently in place, it may be attached by continuous or intermittent fillet welds.*

Whenever practicable, the work shall be positioned so that groove welds are made in the flat position and fillet welds are made in the flat or horizontal position.*

Separation between faying surfaces of lap joints and of the backing in butt joints shall not exceed 2mm. The use of filler plates to correct poor fit is prohibited except as approved by the engineer* and made in accordance with Clause 4.4 of CSA W59.2.

Abutting parts to be joined by groove welds shall be properly aligned. An offset in alignment not exceeding one-tenth of the thickness of the thinner part, but in no case more than 3mm, may be allowed as a departure from the specified alignment. In correcting misalignment in such cases, the parts shall not be drawn in to a slope greater than 1:25. Measurement of offset shall be based on the mid planes of the parts, unless otherwise specified on the drawings.*

Parts to be joined shall be brought into correct alignment or required preset and held in position by such means as fixtures, strongbacks, clamps or guy lines, or tack welds until the welding has been completed. The use of fixtures is recommended when practicable since they can bring the parts into line along the total length. The fixtures or tack welds shall be adequate to resist the forces developed during welding.*

Tack welds shall be made by a qualified welder in accordance with an approved welding procedure, and shall be subject to the same quality requirements as the final welds. Tack welds which are to be incorporated into the final weld shall be made with filler metal of the same composition, and shall be cleaned thoroughly before incorporation. Tack welds not incorporated into final welds shall be removed by mechanical means.*

Temporary welds shall be made by a qualified welder in accordance with an approved welding procedure. Strongbacks, clips, hangers, and other temporary parts that have been welded in place to facilitate assembly shall be removed to give a smooth metal surface, free of defects.*

(d) Allowable Workmanship Tolerances From Detailed Drawings

Tolerances shall be detailed on the individual welding procedure data sheets.

Suggested guidelines of workmanship tolerances are as follows:

1)	Root face	± 1/16" (1.6mm)
2)	Root Opening of Joint with backing	+ 1/4" (6.4mm) - 1/16" (1.6mm)
3)	Root Opening of Joints without backing	± 1/16" (1.6mm)
4)	Groove angle of joint	+ 10° - 5°

(e) Control Of Distortion And Shrinkage Stresses

In assembling and joining parts of a structure or a built-up member, and in welding reinforcing parts to a member, the procedure and sequence shall be such as to minimize distortion and shrinkage.*

Insofar as is practicable, all welds shall be deposited in a sequence that will balance the applied heat of welding while the welding progresses.*

Before the start of welding on a member in which shrinkage or distortion is likely to affect the adequacy of the member or structure, the contractor shall prepare a welding sequence for approval by the engineer, if requested.*

The direction of general progression in welding on members shall be from points where the parts are relatively fixed in position with respect to each other toward points where they have greater relative freedom of movement.*

Joint expected to have larger shrinkage shall normally be welded before joints expected to have lesser shrinkage and with as little restraint as possible.

In making welding under conditions of severe shrinkage restraint, the welding shall be carried continuously to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum specified preheat and interpass temperature.

(f) Weld Terminations

Welds shall be started and stopped in a manner that ensures sound welds.*

If extension bars or run-on and run-off plates are used, they shall be of the same alloy group as the base metal (see Table 5), and shall be removed upon completion and cooling of the weld. The ends of the weld shall be made smooth and flush with the edges of the adjacent parts.*

When it is impossible to terminate a weld on an extension bar or run-off plate, consideration should be given to terminating the weld in a low stress area.*

The techniques for terminating a fillet weld, or a cover pass bead, within a joint include:

(a) reversing the direction of travel for a distance sufficient to create a smooth transition;

(b) increasing travel speed to reduce crater size;

(c) providing suitable build-up, and dressing the crater area flush with the weld surface by mechanical means.*

Crater defects in weld beads, that are intended to be incorporated into final welds, shall be removed by mechanical means prior to additional welding.*

(g) Quality Of Welds

(i) Weld Profiles-

- Insufficient throat is not permitted. *
- Welds shall be free from overlap. *
- Continuous undercut depth shall not exceed the smaller of t/5 or 1mm on each side of the joint, where t is the member thickness. Isolated undercut shall not exceed 2mm in depth, nor shall the length of undercut greater than 1mm in depth exceed 15mm. The intervals between such isolated cases of undercut shall exceed 100mm.*

Groove Welds-

- Reinforcement at the centre of the weld in butt and corner joints shall not exceed the values given in Figure 4 (a) and (b) and, if present, shall be built up uniformly to blend smoothly into the surface of the base metal to a maximum at the centre of the weld.*
- The ends of butt joints shall be of sound metal and maintain the profile of the welded joint.*
- Groove welds shall be free of the defects shown for butt joints in Figure 4(c).*

Fillet Welds-

- The faces of fillet welds shall be in accordance with Figure 1 (a).*

- Fillet welds in any single continuous weld shall be permitted to underrun the nominal size required by 1.5mm without correction, provided that the undersize weld does not exceed 10% of the length of the welds and does not occur at the ends of web-to-flange welds in girders for a length equal to twice the width of the flange.*

- Fillet welds shall be free of the defects shown for fillet weld profiles in Figure 1 (b).*

(ii) Surface Defects-

- Surface cracks in the weld shall not be permitted.*

- Lack of fusion shall not be permitted.*

- Weld termination craters shall not be permitted (see Part F).*

- If surface finishing reveals porosity then the section shall be inspected for internal porosity (see Clause (iii)).*

(iii) Internal Defects-

- Cracks shall not be permitted.*

- Dispersed porosity shall not exceed the limits specified in Figure 12. For linear porosity or similar indications, Table 8 shall apply. (Ref. to CSA W59.2).*

- Individual discontinuities such as porosity, lack of fusion and incomplete penetration shall not exceed the limits specified in Table 8. (Ref. to CSA W59.2).*

(h) Welding Inspection

(i) Visual Inspection-

- The extent of visual inspection by the inspector shall be as stipulated in the contract.*

- A visual inspection procedure and an outline of inspection points shall be prepared by the inspection organization.*

- Inspection shall include material, consumables, surface preparation, fit-up, and welding practices including pre- or post-heat treatment, weld profile, and geometry.*

- Surfaces to be inspected shall be free of any extraneous material or substance which might interfere with interpretation.*

- Welded joints shall be visually inspected to check for the presence of surface discontinuities as given in Clause (g).*

(ii) Non Destructive Testing-

- When nondestructive testing is required as part of the contract, in addition to the visual inspection required in this Standard, it shall be so stated in the information furnished to the bidders. This information shall designate the welds to be examined and the extent of examination of each weld and the method of testing.*

- For detecting discontinuities that are open to the surface, liquid penetrant inspection by the methods set forth in ASTM Standard E165 may be used. Procedures and acceptance criteria shall be in accordance with Clause 7.5 of CSA W59.2.*

- When radiographic inspection is required, the procedures, techniques, and acceptance criteria shall be in accordance with Clause 7.6 of CSA W59.2.*

- When ultrasonic testing is used agreement as to the procedures and acceptance criteria shall be in accordance with Clause 7.7. of CSA W59.2.*

(j) Repair Work

(i) Repair of Defects-

- All welding repairs shall be made by suitably preparing the site of the defect, followed by welding and, if required, finishing the weld flush with the adjacent surface (see Clause 5.12 of CSA W59.2) to satisfy the requirements of Clause (g).*

(ii) Correction of Distortion-

- Members distorted by welding, and requiring rectification shall be straightened at ambient temperature by mechanical means, or by a combination of mechanical means and a controlled amount of localized heat.*

- If localized heating is to be applied in any straightening operation, the complete procedure shall be filed with, and approved by, the engineer. Maximum holding times at various temperatures for aluminium alloys prior to correction of distortion shall be in accordance with Table 7 of CSA W59.2*

**TABLE 1

Specified Minimum Tensile Strengths for Welded Aluminium Alloy (With No Postweld Heat Treatment)

	MINIMUM UTS		MINIMUM YS*	
ALLOY	MPa	(KSI)	MPa	(KSI)
1050	60	(8.7)	20	(2.9)
1060	60	(8.7)	20	(2.9)
1100	80	(11.6)	25	(3.6)
1350	60	(8.7)	20	(2.9)
3003	100	(14.5)	35	(5.1)
3004	150	(21.8)	60	(8.7)
5005	110	(16.0)	40	(5.8)
5052	170	(24.7)	70	(10.2)
5083	260	(37.7)	125	(18.1)
5086	235	(34.1)	105	(15.2)
5154	200	(29.0)	90	(13.1)
5254	200	(29.0)	90	(13.1)
5454	205	(29.7)	90	(13.1)
5456	280	(40.6)	135	(19.6)
6005	170	(24.7)	100	(14.5)
6061	170	(24.7)	110	(16.0)
6063	120	(17.4)	70	(10.2)
6101	130	(18.9)	80	(11.6)
6351	170	(24.7)	110	(16.0)
7004	275	(39.9)	165	(23.9)
7005	275	(39.9)	165	(23.9)

** 0.2% offset in 50mm gauge length*
UTS = ultimate tensile strength
YS = yield strength

* TABLE 1 (CONTINUED)

FILLER ALLOY SELECTION GUIDE

	FILLER ALLOYS															
ASE METAL ALLOYS	413.0, 443.0 A444.0, 356.0 A356.0, A357.0 A359.0	7004 7005,7046 7146,710.0 712.0	6061,6063 6101,6151 6201,6351 6951	5456	5454	5254 5652	5154	5086	5083	5052	5005 5050	3004 ALC 3004	1100 3003 ALC 3003	2219	1060 1350
060,1350	4043	4043	4043	5356	5356	5654	5356	5656	5356	4043	4043	4043	1100	2319	1100
219 100,3003 LCLAD 3003	4145 4043	4145 4043	2319 4043	- 5356	- 5356	- 5654	- 5356	- 5356	- 5356	- 5356	- 4043	2319 4043	2319 1100	2319	
004, ALCLAD 3004	4043		4043	5356	5356	5654	5356	5356	5356	5356	4043	4043			
005,5050	4043	5356	4043	5356	5356	5654	5356	5356	5356	5356	4043				
052	4043	5356	5356	5356	5356	5654	5356	5356	5356	5356					
083	-	5356	5356	5356	5356	5654	5356	5356	5356						
086	-	5356	5356	5356	5356	5654	5356	5356							
154	-	5356	5356	5356	5356	5654	5356								
254,5652	-	5356	5654	5654	5654	5654									
454	-	5654	5356	5356	5554										
456	-	5556	5356	5556											
061,6063,6101 151,6201 351,6951	4043	5256	4043												
004,7005,7046 146,710.0,712.0	4043	5356													
13.0,443.0 444.0 56.0,A356.0 57.0,359.0	4043														

(Continued)

TABLE 1 (CONCLUDED)

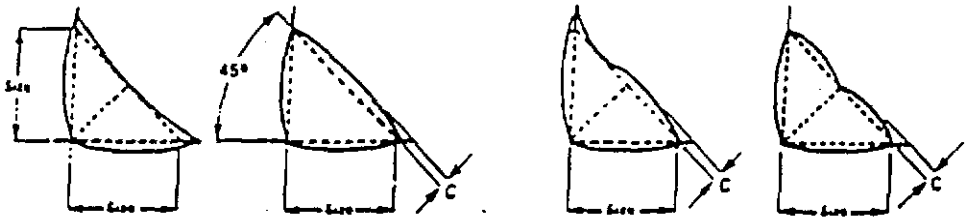
OTES:

1) *Filler alloys 5XXX may be substituted for each other and for filler alloy 4043 in the welding of 3XXX, 5XXX,and 6XXX alloys to modify corrosion resistance, weld metal mechanical properties and for colour match on anodizing. Neither filler alloy 4043 nor 4047 should be used to join 5XXX alloys with Mg levels in excess of 2.5% as excessive formation of $Mg_x Si_y$ lowers weld metal ductility.*

2) *Of the 5XXX series, only filler alloy 5554 is suitable for elevated temperature service (65°C).*

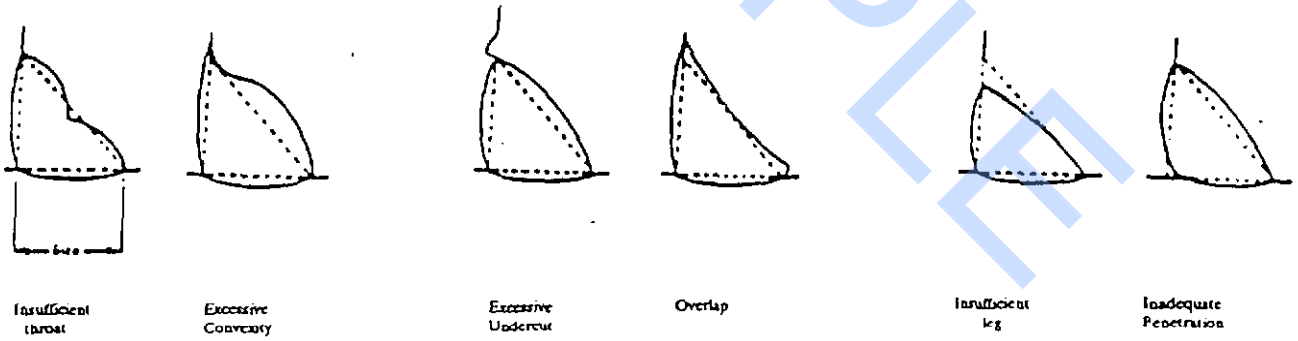
3) *Filler alloy 4043 may be used to join alloys 1XXX and 3XXX for ease of welding on electrical connections, but not for corrosion resistance colour match applications.*

4) *Filler alloy 4047 may be substituted for filler alloy 4043 for joining castings to alloy 1XXX and 3XXX. Filler alloy 4047 has high hot cracking resistance for these applications.*



The convexity shall not exceed: C = 0.1s + 1.5 where s = size in mm

(a) Acceptable Fillet Weld Profiles



(b) Unacceptable Fillet Weld Profiles

* Figure 1
Fillet Weld Profiles

The required size, S, of a fillet weld (see Figure 2) to give an effective throat, E, shall be given by:

$S = 2E \sin(\theta/2) + G$

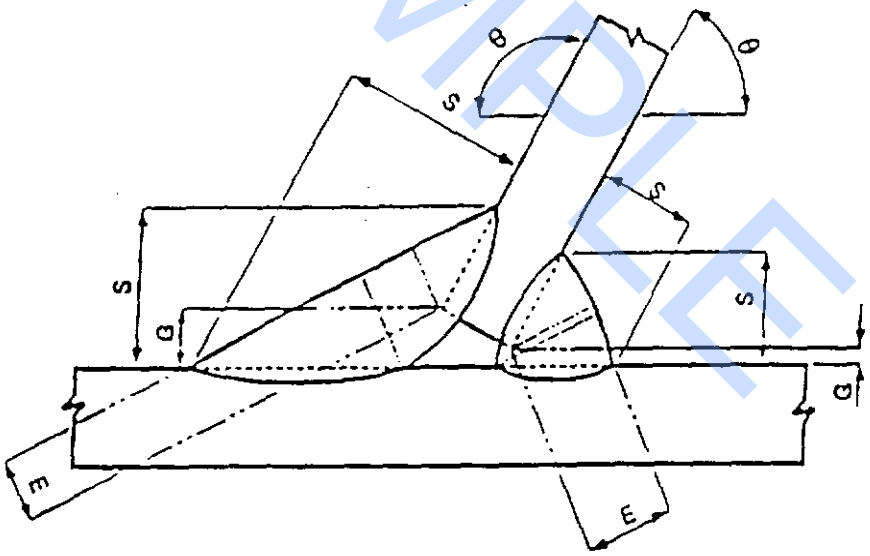
where
G = gap, mm

θ = angle between fusion faces

The gap shall not exceed 5mm, but gaps less than 1mm may be neglected.

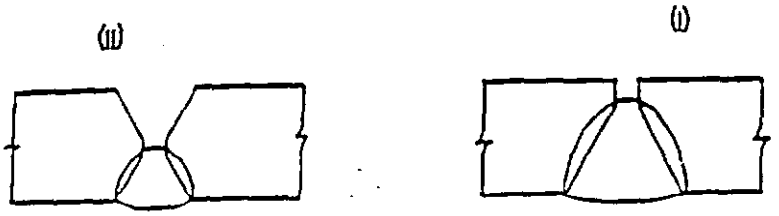
* FIGURE 2

EFFECTIVE THROAT OF FILLET WELDS

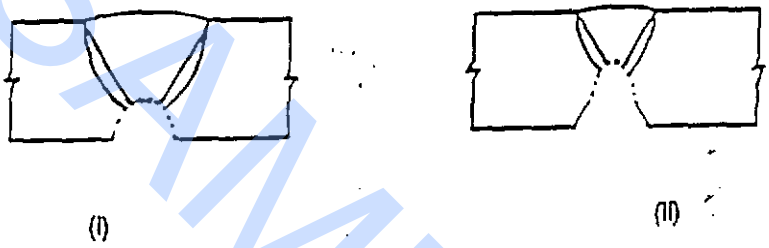


*** Figure 3

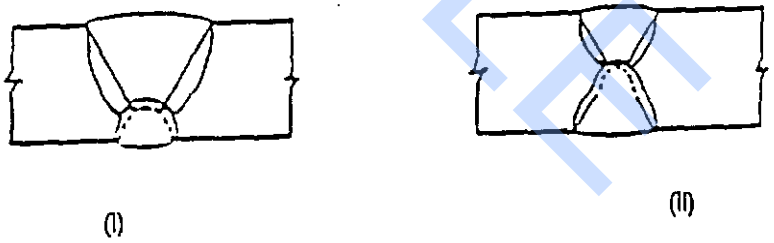
COMPLETE JOINT PENETRATION GROOVE WELDS



(a) First Side Welded

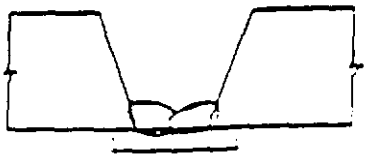


(b) Back of first pass gouged to Sound Metal



(c) Second Side Welded

Preparation. Gouging and Welding of Butt Joints from both sides.



Welding of Butt Joints from one side on Backing

*** TABLE 2**

GROOVE DEPTH OF PARTIAL JOINT PENETRATION GROOVE WELDS

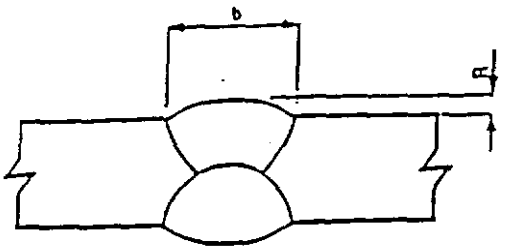
WELD METHOD	GROOVE TYPE	GROOVE ANGLE, O	WELD POSITION	MINIMUM GROOVE DEPTH
GMAW GTAW PAW	J-,U- --- V-bevel	- --- $0 \geq 60°$	all positions	effective throat
GMAW	V-bevel	$45° \leq O < 60°$	Flat, vertical	
GTAW PAW	V-bevel	$45° \leq 0 < 60°$	all positions	effective throat plus 3mm
GMAW	V-bevel	$45° \leq 0 < 60°$	horizontal overhead	

*** TABLE 3**

EFFECTIVE THROAT OF PARTIAL JOINT PENETRATION GROOVE WELDS

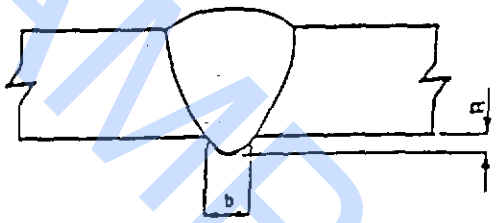
BASE METAL THICKNESS OF THICKER PART JOINED, MM	MINIMUM EFFECTIVE THROAT, MM
3 to 5	2*
Over 5 to 6	3*
Over 6 to 13	5
Over 13 to 20	6
Over 20 to 40	8
Over 40 to 60	10
Over 60 to 150	13
Over 150	16

* *Minimum size for dynamically loaded structures shall be the lesser of plate thickness or 5mm.*



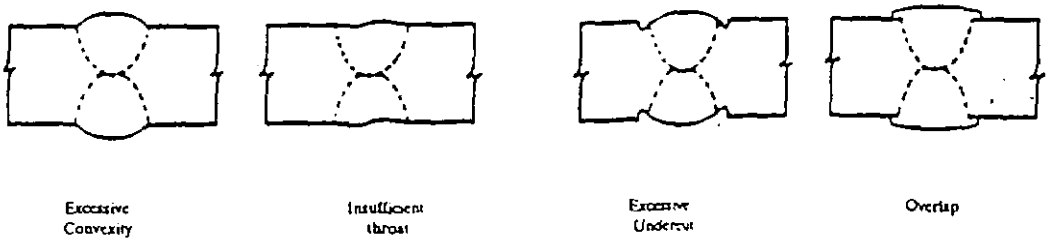
R = convexity
b = weld width
For statically loaded structures R ≤ 1.5 + 0.2b
For dynamically loaded structures R ≤ 1.5 + 0.15b

(a) Acceptable Groove Weld Profiles in Butt Joint Welded from Both Sides



R = convexity
b = weld width
For statically loaded structures R ≤ (1 + 1.2b) ≤ 5
For dynamically loaded structures R ≤ (1 + 0.6b) ≤ 4

(b) Acceptable Groove Weld Profiles in Butt Joint Welded from One Side



(c) Unacceptable Groove Weld Profiles in Butt Joints

* FIGURE 4

GROOVE WELD PROFILES

* TABLE 5

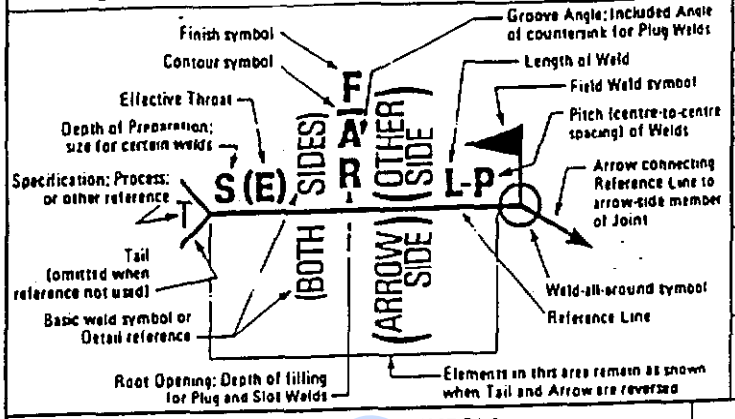
BASE METAL ALLOY GROUPINGS

		NOMINAL COMPOSITION, MASS %								
GROUP	ALLOY	Cu	Mn	Si	Mg	Zn	Cr	Ti	Zr	Al
1	1050	-	-	-	-	-	-	-	-	99.50 min
	1060	-	-	-	-	-	-	-	-	99.60 min
	1100	0.12	-	-	-	-	-	-	-	99.00 min
	11350	-	-	-	-	-	-	-	-	99.50 min
	3003	0.12	1.2	-	-	-	-	-	-	Remainder
2	3004	-	1.2	-	1.0	-	-	-	-	Remainder
	5005	-	-	-	0.8	-	-	-	-	Remainder
	5052	-	-	-	2.5	-	0.25	-	-	Remainder
	5154	-	-	-	3.5	-	0.25	-	-	Remainder
	5254	-	-	-	3.5	-	0.25	-	-	Remainder
	5454	-	0.8	-	2.7	-	0.12	-	-	Remainder
3	5083	-	0.7	-	4.4	-	0.15	-	-	Remainder
	5086	-	0.45	-	4.0	-	0.15	-	-	Remainder
	5456	-	0.8	-	5.1	-	0.12	-	-	Remainder
4	6061	0.28	-	0.6	1.0	-	0.20	-	-	Remainder
	6063	-	-	0.4	0.7	-	-	-	-	Remainder
	6101	-	-	0.5	0.6	-	-	-	-	Remainder
	6351	-	0.6	1.0	0.6	-	-	-	-	Remainder
5	7004	-	0.45	-	1.5	4.2	-	-	0.15	Remainder
	7005	-	0.45	-	1.4	4.5	0.13	0.04	0.14	Remainder

* FILLER METAL ALLOY GROUPINGS

		NOMINAL COMPOSITION, MASS %						
GROUP	ALLOY	Cu	Mn	Si	Mg	Cr	Ti	Al
1	5183	-	0.8	-	4.8	0.15	-	Remainder
	5356	-	0.12	-	5.0	0.12	0.13	Remainder
	5554	-	0.8	-	2.7	0.12	0.12	Remainder
	5556	-	0.8	-	5.1	0.12	0.12	Remainder
	5654	-	-	-	3.5	0.25	0.10	Remainder
2	4043	-	-	5.2	-	-	-	Remainder
	4047	-	-	12.0	-	-	-	Remainder
	4145	4.0	-	10.0	-	-	-	Remainder
3	1100	0.12	-	-	-	-	-	99.0% min

LOCATION OF ELEMENTS OF A WELDING SYMBOL



BASIC WELDING SYMBOLS and THEIR LOCATION SIGNIFICANCE

Location Significance	Fillet	Plug or Slot	Back or Backing	Stud	Arc Spot
ARROW SIDE			Groove Weld Symbol		
OTHER SIDE			Groove Weld Symbol	Not Used	
BOTH SIDES		Not Used	Not Used	Not Used	Not Used
No Arrow Side or Other Side Significance	Not Used	Not Used	Not Used	Not Used	Not Used

SUPPLEMENTARY SYMBOLS

Weld All-Around	Field Weld	Melt-Thru	BACKING, SPACER, OR CONSUMABLE INSERT	CONTOUR: Flush	CONTOUR: Convex	CONTOUR: Concave

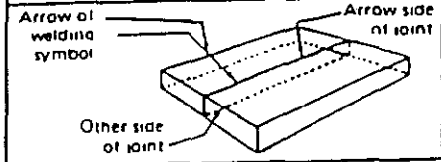
Where process abbreviations are to be included in the tail of the welding symbol, reference is made to Table A, Designation of Welding and Allied Processes by Letters, of AWS 2.4-79

11 FLUSH CONTOUR SYMBOL

Flush contour symbol indicates face of weld to be made approximately flush.

When used without a surface finish symbol, it indicates weld without subsequent finishing

1 BASIC JOINTS BUTT JOINT



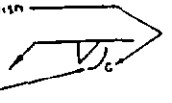
6 WELD-ALL-AROUND SYMBOL

Weld-all-around symbol indicates that weld extends completely around the joint

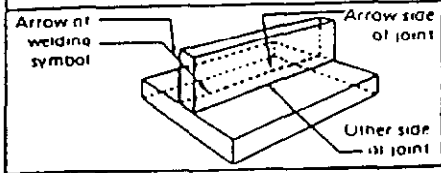
12 CONVEX CONTOUR SYMBOL

Finish symbol (user's standard) indicates method of obtaining specified contour but not degree of finish

Convex contour symbol indicates face of weld to be finished to convex contour by grinding



2 BASIC JOINTS T-JOINT



7 FIELD WELD SYMBOL

Field weld symbol indicates that weld is to be made at a place other than that of initial construction

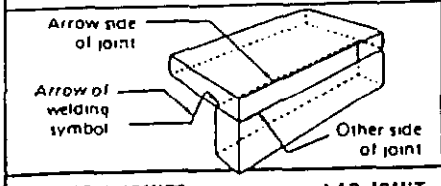
Flag points away from the arrow (WSB recommendation)

13 COMPLETE JOINT PENETRATION

Indicates complete joint penetration groove weld regardless of type of weld and joint preparation

To be used on design drawing only (see Clause 4.1.1.1.4)

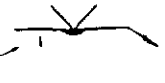
3 BASIC JOINTS CORNER JOINT



8 MELT-THRU SYMBOL

Any applicable weld symbol

Size (height)
– Omission indicates no special height desired



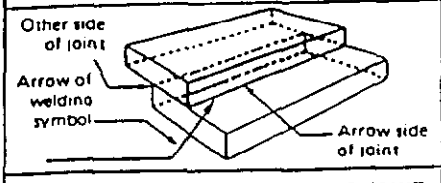
14 MULTIPLE REFERENCE LINES

First operation shown on reference line nearest arrow

Second operation, or supplementary data

Third operation, or test information

4 BASIC JOINTS LAP JOINT



9 JOINT WITH BACKING

With groove-weld symbol

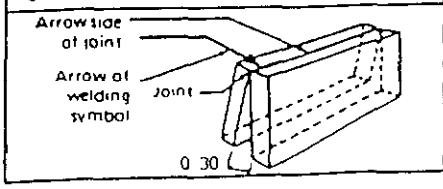
NOTES
– Material (M) and dimensions of backing as specified.
– "R" indicates backing removed after welding.
– See Clause D1.6

15 FINISHING OF WELDS

Finishing of welds other than cleaning is indicated by suitable contour and finish symbols. The following finishing symbols indicate the method, not the degree, of finish:

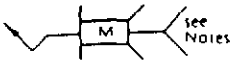
C – Chipping
G – Grinding
M – Machining
R – Rolling
H – Hammering

5 BASIC JOINTS EDGE JOINT



10 JOINT WITH SPACER

With modified groove-weld symbol



NOTES
– Material (M) and dimensions of spacer as specified
– See Clause D1.6

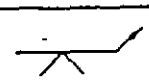
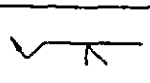
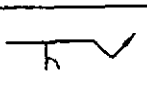
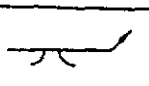
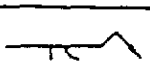
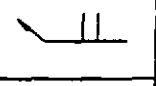
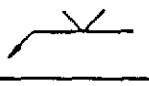
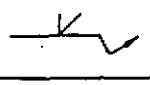
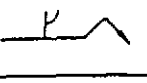
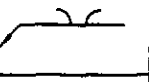
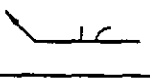
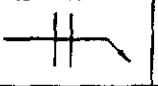
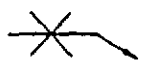
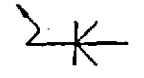
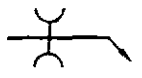
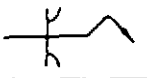
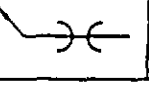
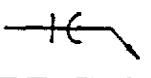
Double-bevel symbol

16 ABBREVIATIONS

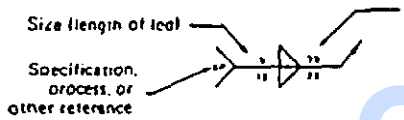
GTSM;– Gouge To Sound Metal
CP – Complete Penetration
PP – Partial Penetration

Extracted from W59.2-M1991

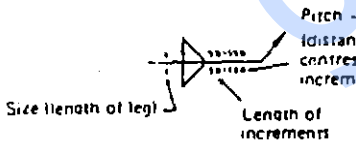
BASIC WELDING SYMBOLS AND THEIR LOCATION SIGNIFICANCE

Square Groove	V-Groove	Bevel-Groove	U-Groove	J-Groove	Flare-V-Groove	Flare-Bevel-Groove	Location Significance
							ARROW SIDE
							OTHER SIDE
							BOTH SIDES

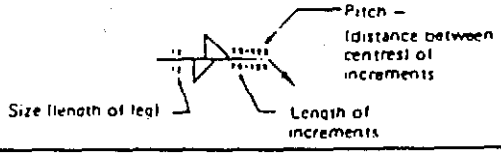
17 DOUBLE-FILLET WELDING SYMBOL



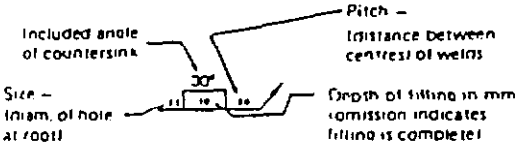
18 CHAIN INTERMITTENT FILLET WELDING SYMBOL



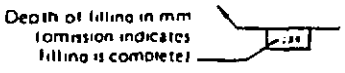
19 STAGGERED INTERMITTENT FILLET WELDING SYMBOL



20 PLUG WELDING SYMBOL

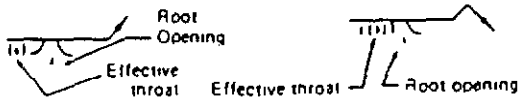


21 SLOT WELDING SYMBOL



Orientation, location, and all dimensions other than depth of filling as shown on the drawing

22 FLARE-V AND FLARE-BEVEL-GROOVE WELDING SYMBOLS

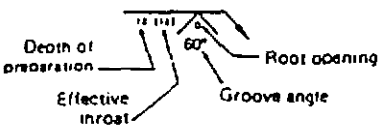


23 SQUARE-GROOVE WELDING SYMBOL

For square groove the depth of preparation is omitted in the symbol

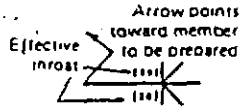
Omission of effective throat without designating the weld as "seal weld" in the tail of the symbol indicates complete joint penetration is required

24 SINGLE-V-GROOVE WELDING SYMBOL



Omission of depth preparation and effective throat indicates complete joint penetration is required.

25 DOUBLE-BEVEL-GROOVE WELDING SYMBOL



Omission of depth of preparation and effective throat indicates total depth of preparation — symmetrical in case of double-groove welds — equal to the thickness of the member and, hence, complete joint penetration groove weld is required

26 WELDING SYMBOL FOR GROOVES WELDED FROM BOTH SIDES WITH BACKGOUGING

Only depth of preparation is required in the welding symbol

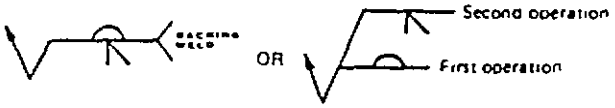
GTSM signifies total effective throat is equal to the thickness of material. See Clause D1.2 of Appendix D.

27 BACK-WELDING SYMBOLS

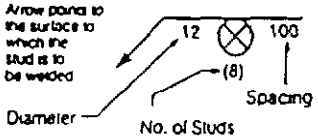
Any single-groove weld with a pass from the Other side with no special identification in the tail is considered a groove weld with a back weld

28 BACKING WELDING SYMBOLS

Any single-groove weld with a pass from one side identified in the tail by "backing weld" is considered to be a groove weld with a backing weld.

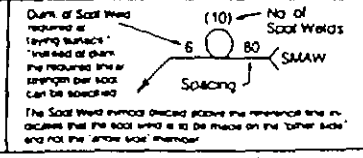


29 STUD WELDING SYMBOL



NOTES:
(1) - Stud Weld symbol is always below the reference line
(2) - the location of the first and last Stud Weld in each single line shall be specified on the drawing

30 ARC SPOT WELDING SYMBOL



NOTES:
(1) - Arc Spot Weld symbols can be placed above or below the reference line, depending on whether welding is to be done on the "other side" or the "arrow side" member respectively
(2) - The location of the first and last arc spot weld in each single line shall be specified on the drawing

Extracted from W59.2-M1991

BIBLIOGRAPHY

Those items marked with an asterisk have been extracted in whole or in part from:

CSA W59.2-M1991 WELDED ALUMINIUM CONSTRUCTION, CANADIAN STANDARDS ASSOCIATION, 1991, REXDALE, ONTARIO, CANADA.

Those items marked with a double asterisk have been extracted in whole or in part from:

CSA W47.2-M1987 CERTIFICATION OF COMPANIES FOR FUSION WELDING OF ALUMINIUM,
CANADIAN STANDARDS ASSOCIATION, 1987, REXDALE, ONTARIO, CANADA.

Those items marked with a triple asterisk have been extracted in whole or in part from:

CSA W59-M1989 WELDED STEEL CONSTRUCTION (METAL ARC WELDING),
CANADIAN STANDARDS ASSOCIATION, 1989, REXDALE, ONTARIO, CANADA.

COMPANY NAME:

COMPANY ADDRESS:

W47.2/W59.2

WELDING PROCEDURE SPECIFICATION FOR GAS TUNGSTEN ARC WELDING OF ALUMINUM

SPECIFICATION No.:

Scope

This Welding Procedure Specification covers welding and related operations of aluminum structures which are fabricated in accordance with CSA Standard W59.2, "Welded Aluminum Construction", and has been prepared to meet the requirements of Clause 7.1 of CSA Standard W47.2, "Certification of Companies for Fusion Welding of Aluminum".

A change in any of the essential variables contained in the succeeding paragraphs or detailed on an applicable welding procedure data sheet will require a new welding procedure specification and/or a new data sheet.

Welding Process

The welding shall be done using the Gas Tungsten Arc Welding (GTAW) process.

Joints shall be made by single or multiple pass welding, from one or both sides, as indicated on the approved Welding Procedure Data sheets referring to this specification.

Base Metal

The base metal alloys used shall conform to the materials listed in Table 1A of CSA Standard W47.2. Other alloys may be welded provided approved data sheets are available.

Base Metal Thickness

Base metal from 3.0 mm to unlimited thickness may be welded under this specification provided that the Welding Procedure Data Sheets have been supplied and approved by the Canadian Welding Bureau. Thicknesses less than 3.0 mm may be welded providing data sheets have been approved by the Canadian Welding Bureau.

	X
CWB	**ENGINEER OR SUPERVISOR**

X *This space to be stamped by P. Eng. if Div. 1 or Div. 2 company.*

Welding Supervisor's Signature if Div. 3 company.

Filler Metal

Filler metal shall be certified by the Canadian Welding Bureau as conforming to the requirements of ANSI/AWS Standard A5.10.

The choice of filler metal shall be in accordance with Table 3 of CSA Standard W59.2.*

Filler metal shall be stored in a dry, clean place adequately protected from the weather or environment hazards until actually needed. The storage area temperature shall be maintained at a uniform temperature approximately the same as that of the welding location.

Precautions shall be taken to ensure that all opened packages of filler rods or spools of electrode wire are protected from the weather or other contaminants. Filler metals that are contaminated with foreign matter shall not be used.*

Shielding Gas

The shielding gas shall be welding grade argon, helium, or an argon-helium mixture and shall be limited to those specified on the fabricator's approved welding procedure data sheets. The welding gases shall have a dew point of -40° Celsius, or lower, at 101 kPa.

The gas distribution system shall be free from leaks to prevent air or other contaminants from entering. The containers or storage systems should not be used when the pressure falls below 2000 kPa (290 psi).*

Position

The welding shall preferably be done in the flat position. The horizontal, vertical and overhead positions may be used provided approved Welding Procedure Data Sheets referring to those positions and the Welding Procedure Specification are followed.

Preheat/Heat Treatable Alloys

Preheat is not normally required when fusion welding aluminum, however, when welding thick sections, preheating is sometimes used to avoid cold-start defects, to achieve heat balance between dissimilar thickness or to remove moisture. Care shall be taken to ensure temperature control, particularly, when fabricating the heat treatable and the 5XXX series alloys that contain more than 3% magnesium.

When fabricating heat treatable and 5XXX alloys containing more than 3% magnesium, the interpass temperature shall be allowed to fall below 150° Celsius before starting the next pass.*

Electrical Characteristics

The welding current shall be alternating or direct current with positive or negative electrode. In general, ACHF (high frequency) is preferred for welding aluminum.

MANUFACTURER'S RECOMMENDED WELDING PARAMETERS

This table shows the recommended parameters for all electrodes to be covered by this specification.

Shielding Gas	Filler Metal Classification	Filler Metal Diameter	Position	Tungsten Diameter & Type	Amperage	Polarity	Voltage	Electrode Stickout	Nozzle Size

Welding Technique

When AC TIG welding of aluminum, it is good practice to "ball" or round the end of the electrode before welding to keep the arc steady. Otherwise, the arc may weave or move from side to side. DC welding of aluminum may be used; however, each joint design and welding specification requires its own procedure.

AC TIG Welding

Before welding is started, electrode size, current setting and gas flow should be selected to suit the material thickness and welding position being used from an approved data sheet.

Striking the Arc: When the electrode is brought within 1/8" to 1/16" of the plate, the welding arc will be initiated. The arc is then adjusted to the desired length. When hot, the electrode must not touch the work or contamination will result. This contamination will cause a dirty sputtering arc that will not produce a clean or satisfactory weld instead of the smooth humming sound that is desired. The arc length should be from 3mm to 10mm (1/8 to 3/8 inch) depending on the location and the type of joint being welded.

The torch angle is usually 5 to 15° forehand and the work angle 90° when welding in the flat position (see Fig. 1). The arc may have to be directed at the thicker member to obtain equal melting when joining unequal thicknesses. Hold the torch at the starting point until the arc has produced a bright, clean puddle of molten base metal (approx. 3 - 5 seconds). Move the torch steadily forward at a uniform rate while feeding the filler rod to the leading edge or side of the puddle. Do not add filler material until a good puddle has been established. Hold the welding rod at an angle of 20 to 30° to the work, slightly off centre to the line of the joint, and feed into and withdraw from the molten puddle (but not out of the shielding gas) at frequent, regular and short intervals. The torch is moved back slightly when the filler is added to allow the filler rod to be introduced into the molten puddle.

The torch is then moved forward to advance the puddle once the required bead size is obtained. This backward and forward motion is repeated smoothly and uniformly in steps of approximately 1.5 - 5mm (1/16 to 3/16 inch). When no filler material is being used, it is not necessary to use this motion.

When breaking the arc, withdraw the torch from the work while the filler rod is still being added to feed the crater as it solidifies. The arc is run onto the cold filler rod as the gun is withdrawn and is broken quickly. The arc may have to be re-struck several times while adding filler if the crater is not completely filled. To produce crater-free stops on thin gauge material or on shallow weld beads, increase the arc travel speed. This increase in speed should be sufficient to eliminate the melting of the parent metal. Use run-on and run-off tabs wherever possible.

Other positions (horizontal, vertical and overhead) are also practical when TIG welding. The techniques are, in general, the same as described above for the flat position, except that slightly lower current are used. This lower current will keep the weld puddle small enough to prevent it from sagging before solidification takes place.

Figure 1

Preparation of Material

Edge preparation may be accomplished by disc grinding, shearing, plasma-arc cutting, sawing, chipping, planing, milling, or routing.

When disc grinding is used for edge preparation, high speed flexible grinding discs shall be used. The grinding disc shall be suitable for aluminum and be maintained free of lubricants and other foreign material.

When shearing is used for edge preparation, the shear blade shall be kept sharp and free of foreign material. The sheared edge of aluminum shall be filed, planed or routed to remove any metal that can possibly entrap foreign material such as cutting oil.

To allow for effective cleaning, surfaces and edges to be welded shall be smooth, uniform and free from fins, cracks and other defects that could introduce porosity or oxides into the weld.

All surfaces to be welded shall be wire brushed prior to welding to remove existing oxides. 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 aluminum and be kept clean and free of contaminants.

When plasma arc cutting is used for the edge preparation of heat-treatable alloys, 3mm of material shall be removed from the cut edges by mechanical means. This includes both butt and T-joints. Note, plasma arc cutting heat treatable aluminum alloys may produce lamellar fissures.

Cleaning should be done just prior to welding but if welding is delayed, the cleaned material shall be covered with polyethylene sheeting, paper or other similar protective covering, to guard against contamination.

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.

Note: *Equipment used for preparing aluminum should be used solely for this purpose to prevent contamination of the base material from foreign materials.*

Weld Quality

Insufficient throat is not permitted.**

Weld termination craters shall not be permitted.**

If the surface finishing reveals porosity then the section shall be inspected for internal porosity.**

Welds shall be free from cracks, lack of fusion, lack of penetration, and essentially free from undercut, overlap, or surface porosity.**

Continuous undercut depth shall not exceed the smaller of T/5 or 1 mm on each side of the joint, where T is the member thickness.**

Isolated undercut shall not exceed 2 mm in depth. Undercut greater than 1 mm in depth shall not have a length greater than 15 mm, and shall not be closer than 100 mm to another 2 mm undercut.**

Fillet welds shall have a degree of convexity not exceeding 0.1s + 1.5 mm where s = size of the minimum leg length in mm.**

Fillet welds shall conform to the profiles shown in Fig. 11 of W59.2. Fillet welds shall be free of the defects shown in Fig. 11 of W59.2. **

Essential Variables

The following are considered essential variables for Gas Tungsten Arc Welding (GTAW) as per Clause 8.2.3.4 of CSA Standard W47.2:

(1) a change in base metal alloy group as per Table 1A of CSA W47.2;
(2) a change in filler metal alloy group as per Table 1B of CSA W47.2;
(3) the omission of aluminum backing material or the substitution of other than aluminum backing material;
(4) a change in current of ± 15% and/or arc voltage of ± 2V;
(5) a change from ac current to dc current, or vice versa;
(6) a change from dc electrode negative to dc electrode positive, or vice versa;
(7) a change from constant current to pulsed current, or vice versa;
(8) a change of ± 25% from the specified travel speed;
(9) a change of ± 25°C in the specified preheat;
(10) a change from a single gas to any other single gas; a change from a single gas to a mixture of gases or vice versa; a change of ± 10% in the specified composition of gas mixture;
(11) an increase of 50% or more, or a decrease of 20% or more, in the flow rate of shielding gas;
(12) a change of electrode size;
(13) a change in welding position, except as provided for in Clause 8.3.1 of CSA W47.2;
(14) a change in direction of progression in vertical welding;
(15) a change in specified joint geometry;
(16) a change from welding from one side to welding from both sides or vice versa;
(17) a change of cleaning procedure.

Data Sheets

The attached data sheets form part of this specification.**

BIBLIOGRAPHY

Those items marked with an asterisk have been extracted in whole or in part from:

CSA W59.2-M1991 WELDED ALUMINUM CONSTRUCTION, CANADIAN STANDARDS ASSOCIATION, 1991, REXDALE, ONTARIO, CANADA.

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