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RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	8/16/04	Initial issue.	Kelly Bingham, *FWO-DECS*	Gurinder Grewal, *FWO-DO*
1	10/27/06	Administrative changes only. ISD number changed based on new Conduct of Engineering IMP 341. Other administrative changes.	Kelly Bingham, *FM&E-DES*	Kirk Christensen, *CENG*

Contact the Welding Standards POC for upkeep, interpretation, and variance issues

WFP 2-05	**Welding POC/Committee**

WFP 2-05 AWS D1.2, STRUCTURAL ALUMINUM

1.0 PURPOSE AND SCOPE

A. This welding procedure shall govern the welding of components to the requirements of AWS D1.2 (Reference 1). The Code edition and addenda for this procedure shall be the latest in effect or as otherwise specified by engineering requirements.

B. The use of AWS standard welding procedure specifications shall be in accordance with GWS 1-02, *Administrative Control of Welding.*

2.0 REFERENCES

1. AWS D1.2, "Structural Welding of Aluminum"

3.0 WELDER QUALIFICATION

A. Welder/welding operators shall be currently certified, having performed qualification tests in accordance with GWS 1-05, *Welder Performance Qualification & Certification*.

4.0 WELDING PREREQUISITES

A. All welding shall comply with the requirements specified in the Welding Procedure Specification (WPS) or Welding Technique Sheet (WTS).

B. Welding shall not be performed when the ambient temperature in the immediate vicinity of the weld is lower than 0 °F or when surfaces are wet or exposed to rain, snow, or wind or draft exceeds 5 mph or when the welder or the weld joint is exposed to such inclement conditions. If the ambient environmental temperature is below 32 °F, a heated structure or shelter shall be provided that will maintain the temperature adjacent to the weldments at 32 °F or higher.

C. When the base material is below the minimum temperature identified in the WPS or WTS, the material shall be preheated to, or above the allowable minimum temperature for a distance equal to the thickness of the parts being joined, but not less than 3 in.

D. Care shall be taken to assure that moisture has not been trapped between members that are to be welded and that moisture has not been introduced into previously fit-up joints prior to final welding. This preheating is to be done before welding is started to drive moisture from the region of the weld.

5.0 MATERIALS

A. Base Materials

1. Only the materials specified in the WPS or WTS may be welded using this procedure.

B. Filler Materials

1. Welding filler materials to be used with this procedure are specified in the WPS or WTS. A listing of applicable welding filler materials is provided in GWS 1-07, *Material Specifications*.
2. Requirements for the purchase and control of welding filler material shall be in accordance with GWS 1-03, *Welding and Brazing Material Procurement and Control*.
3. Welding filler materials (wire electrodes, bare filler wire, or consumable inserts) must be utilized by welders making weldments with this procedure. Welders shall not perform welds autogenously.

6.0 BASE MATERIAL JOINT PREPARATION

A. Surfaces and edges to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other discontinuities that would adversely affect the quality or strength of the weld.

B. Members to be joined may be cut to shape and size by machining, shearing, sawing, plasma arc cutting, chipping, planning, milling, routing, or grinding.

C. For heat treatable aluminum alloys to be welded, 1/8 in. of the material shall be removed from plasma arc cut edges by machining or other mechanical means. Plasma cut edges of heat treatable aluminum alloy material may be used without machining when the parts will not be welded. Kerf or gouge marks on the joint bevel deeper than 1/8" shall be repaired prior to fit-up and tack welding.

7.0 BASE MATERIAL JOINT CLEANING

A. Prior to welding, surfaces for welding shall be clean and free from paint, oil, oxidation, grease, and any other foreign materials that are detrimental to welding.

B. Solvents approved for use on the base material and weld materials are methyl alcohol, ethyl alcohol, isopropyl alcohol, acetone, methyl ethyl keytone, toluene, Varson 4, Dowanol EB, and Stoddard solvents.

8.0 JOINT FIT-UP AND ALIGNMENT

A. The root opening and fit-up tolerances shall be as specified in the WPS or and GWS 1-06, *Weld Joint Design*. If the tolerances cannot be achieved, the end preparations may be built up by welding in accordance with a WPS or WTS and re-prepared by filing, machining, or grinding.

B. The parts to be joined by a tee or fillet weld shall be brought into as close contact as is practicable. The maximum gap between these parts shall not exceed $^{1}/_{16}$ in. except in the cases involving rolled or extruded shapes or plates 3 in. or more in thickness. When after straightening and assembly, the root opening cannot be closed sufficiently to meet this tolerance, a maximum separation of $^{5}/_{16}$ in. is acceptable, provided a sealing weld or suitable backing is used to prevent melt-through. If the separation is greater than $^{1}/_{16}$ in. each leg of the fillet weld shall be increased by the amount of separation or that the required effective throat has been obtained.

C. The gap between faying surfaces of lap joints or butt welds utilizing backing shall not exceed $^{1}/_{16}$ in.

D. Parts to be joined by butt-welding shall be carefully aligned to maintain an offset not exceeding 10 % of the thickness of the thinner part joined, but in no case more than $^{1}/_{8}$ in. shall be permitted as a departure from the theoretical alignment. In correcting misalignment in such cases, the parts shall not be drawn into a greater slope than ½ in. in 12 in. Measurement of offset shall be based upon centerline of parts unless otherwise shown on the drawing.

E. The parts to be joined by partial penetration groove welds parallel to the length of the member (bearing joints excepted) shall be brought into as close contact as practicable. The root gap between parts shall not exceed $^{3}/_{16}$ in. except in the cases involving rolled or extruded shapes or plates 3 in. or more in thickness. When after straightening and assembly, the root opening cannot be closed sufficiently to meet this tolerance, a maximum separation of $^{5}/_{16}$ in. is acceptable, provided a sealing weld or suitable backing is used to prevent meal-through. Tolerance for bearing joints shall be in accordance with the engineering documents.

9.0 TACK WELDS

A. Tack welds shall be made by a qualified welder in accordance with an approved WPS or WTS and are subject to the same quality requirements as the final weld.

B. Acceptable tack welds may be incorporated into the final weld.

C. Defective tack welds shall be removed or repaired prior to welding.

10.0 BACKPURGE/GAS BACKING

No requirements.

11.0 PREHEAT AND INTERPASS TEMPERATURE

A. Inter-pass temperatures shall not exceed the maximum value specified in the WPS or WTS and shall be checked on the surface of the component using a surface pyrometer, "Tempilstick," or non-mercury-type thermometer. Temperature indicating crayons shall not be used directly in the weld zone.

B. If the temperature of the weld is above the maximum interpass temperature specified in the WPS or WTS, the weld shall be allowed to cool down below the maximum interpass temperature, but not below the minimum preheat temperature, prior to resumption of welding.

C. When fabricating heat treatable aluminum alloys or 5000 series aluminum- magnesium alloys containing more than 3 percent magnesium, the preheat and interpass temperature shall not exceed 250 F (120C). Holding times at these temperatures shall not exceed 15 minutes.

12.0 WELD TECHNIQUE

A. Welding voltage and amperage shall be in accordance with the limits specified in the WPS or WTS. Voltage and amperage range gages located on the welding power supply are for reference only and are not mandatory check or hold points. Voltage and amp range checks for documentation purposes shall be performed by a qualified (CWI or equivalent) inspector using calibrated voltage and amp meters or approved welding parameter recording equipment.

B. Defects that appear on the surface of a weld bead shall be removed by rotary filing, grinding, or chipping, before depositing the next bead.

C. Before welding over previously deposited material, the weld and adjacent base material within 1" on either side of the weld shall be brushed clean.

D. For double-welded butt joints, before applying weld material on the second side to be welded, the root shall be prepared by suitable methods such as chipping, grinding, to ensure sound material.

E. The minimum size of a root pass shall be sufficient to prevent cracking.

F. The maximum thickness of root passes in groove welds shall be ¼ in.

G. The maximum size of single-pass fillet welds and root passes of multiple-pass fillet welds shall be:

- $^{3}/_{8}$ in. in the flat position
- $^{5}/_{16}$ in. in the horizontal and overhead positions
- ½ in. in the vertical position.

H. The maximum thickness of layers subsequent to root passes of groove and fillet welds shall be:

- $^{1}/_{8}$ in. for the flat position
- $^{3}/_{16}$ in. for vertical, overhead, and horizontal positions.

I. Peening

1. Peening of materials may be used to control distortion or to relieve residual stresses with the approval of the Engineer or WPA. Peening shall not be performed until $^{3}/_{8}$ in. (10 mm) depth of bevel has been deposited. Peening shall not be applied to cover passes, base material, or weld layers requiring nondestructive examination. Peening shall not be used to mask a defect.

J. Control of Distortion and Shrinkage

1. In assembling and joining parts of a structure or of built-up members and in welding reinforcing parts to members, the procedure and sequence shall be minimize distortion and shrinkage.
2. Insofar as practicable, welds shall be deposited in a sequence that will balance the applied heat of welding while the welding progresses.
3. The welding sequence applied, in conjunction with the WPS or WTS and overall fabrication methods, shall produce members or structures meeting the specified quality requirements.
4. The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other toward points where they have a greater relative freedom of movement (back welding).
5. Joints expected to have significant shrinkage should usually be welded before joints expected to have lesser shrinkage. Such joints should be welded with as little restraint as possible.

6. In making welds under conditions of severe external shrinkage restraint, the welding shall be continuous to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum specified preheat temperature.
7. When members are distorted by welding they may be straighten by mechanical means at ambient temperature or by localized heating in conjunction with mechanical methods. When localized heating method is used it shall be accomplished in accordance with an approved procedure, which meets the temperature values listed in Table 3.2 of Ref. 1.

K. All welding processes may be single pass or multiple passes per side unless otherwise specified in the Welding Procedure Specification (WPS) or Welding Technique Sheet (WTS).

1. Welding shall be performed single arc unless otherwise specified in the WPS or WTS.

L. Welding processes permitted by this procedure; GTAW, PAW, & GMAW. All other processes shall be approved by the LANL WPA.

13.0 INSPECTOR QUALIFICATION

A. The Inspector who performs welding inspection for acceptance to this procedure shall be an AWS-CWI, and authorized by the LANL WPA.

14.0 ACCEPTANCE CRITERIA FOR COMPLETED WELDS

A. Butt Welds

1. As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys.
2. The surface condition of the finished welds shall be suitable for the proper interpretation of radiographic and other nondestructive examinations when nondestructive examinations are required. In those cases where there is a question regarding the surface condition on the interpretation of a radiographic film, the film shall be compared to the actual weld surface for interpretation and determination of acceptability.
3. Undercut shall not exceed the following:

- Dynamically Loaded Structures

Thickness	Primary Stress Direction	Maximum Undercut
a) 1/8>1 in.	Transverse	0.01
b) Over 1 in.	Transverse	1/32 in
c) All thick nesses	Parallel or None	1/32 in

- Statically Loaded Structures

  The undercut shall not exceed 0.01 in. in primary stress directions category applicable to the area containing the undercut. The undercut may be twice the value permitted for the applicable stress category for an accumulated length of 2 inches in any 12 in. length of weld, but in no case may the undercut on one side be greater than 1/16 in. For weld length less than 12 in., the permitted length shall be proportional to the actual length.

- Class 1 Tubular Structures

  The undercut shall not exceed the value shown in Figure 9.4 of reference 2.1 for primary stress directions category applicable to the area containing the undercut. Further, the undercut may be twice the value permitted by Figure 9.4 (for the applicable stress category) for an accumulated length of 2 in. in any 12 in. length of weld, but in no case may the undercut on one side be greater than 1/16 in. For weld length less than 12 in., the permitted length shall be proportional to the actual length.

- Class 2 Tubular Structures

Length, each undercut	Depth	Distance between undercut
0.20 in. Maximum	15% or Minimum	2.0 in. base material thickness

4. Reinforcement shall not exceed the profiles given in Attachment 3.1 and shall have gradual transition to the plane of the base material surface. For class 1 tubular structures the maximum reinforcement permitted is 1/8 in.
5. Groove welds shall be terminated at the ends of a joint in a manner that will ensure sound welds. This shall be done by use of extension bars or runoff plates or by grinding starts and stops. After the weld is completed, the extension bars or runoff plates shall be removed and the junction ground flush.
6. Grove or fillet weld terminations in dynamically loaded joints in primary structures subject to fatigue loads shall require terminations made by one for the following techniques:
   - Reversing directions for a minimum of 2 in.; or
   - Increasing travel speed to reduce crater size; or
   - Both of the above; or
   - Providing build up and removing excess build up by mechanical means.
7. In class 2 tubular structures the underfill of root penetration and reinforcing of completed groove weld shall be 15% maximum of the minimum base material thickness. For complete joint penetration groove welds, an underfill condition of the reinforcing and root penetration bead shall not be permitted to coincide at any given length of weld. The length of underfill shall not exceed 0.75 in and not more than 1.5 in. cumulative in any 6 in. of weld.

B. Fillet Welds

1. As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys and shall suitable for the proper interpretation of nondestructive examinations.
2. The fillet weld in any single continuous weld may be less than the specified fillet size by up to and including $^{1}/_{16}$ in. with correction, provided that the undersized portion of the weld does not exceed 10% of the length of the weld. On web-to-flange welds on girders, fillet weld sizes less than the specified size shall be prohibited at the end for a length equal to twice the width of the flange.

3. Fillet welds may vary from convex to concave. The size of a fillet weld is determined as shown in Attachment 1.
    - Class 1 Tubular Structures fillet weld throat criteria:

        a) Convexity 0.15S + 0.060 in. where S = largest specified leg size.
        b) Concavity throat shall not be undersized.

    - Class 2 Tubular Structures fillet weld throat criteria:

        a) Convexity shall be 20% of theoretical throat, maximum
        b) Concavity is permissible only if required throat depth is maintained

4. Weld beads shall be continuous through high stress areas such as corners.
5. The minimum fillet weld size, except for fillet welds used to reinforce groove welds, all to be in accordance with drawings or applicable sections of Reference 1.
6. The maximum fillet weld size detailed along edges of material shall be in accordance with drawings or applicable sections of Reference 1.

C. Arc Strikes

1. Cracks or blemishes outside of the area of permanent welds resulting from arc strikes shall be ground to a smooth contour and checked to ensure soundness. For tubular structures scratch or arc/burn marks, the examination criteria shall be the same as undercut in Paragraph 14.A.3 (third bullet).

D. Copper or tungsten inclusions

1. Copper or tungsten inclusions deposited during welding shall be removed to sound material.

15.0 WELD REPAIRS

A. Weld repairs shall be performed using the original WPS or WTS or an alternate WTS specific to each repair to restore a weld to an acceptable condition.

B. The Engineers welding inspector shall be notified before improperly fitted and unacceptable members are cut apart

C. The removal of weld material or portions of the base material may be done by machining, grinding, or chipping. It shall be done in such a manner that the remaining weld material or base material is not nicked or undercut. Unacceptable portions of the weld shall be removed without substantial removal of the base material. The repaired area to be welded shall be thoroughly cleaned before any welding is performed. The weld material added to compensate for any deficiency in size of the weld shall be deposited by a qualified welder with filler material of the same composition in accordance with the approved WPS or WTS.

D. The weld shall be corrected as follows:

1. Overlap or Excessive Convexity - Remove excess weld material.
2. Excessive Concavity of Weld or Crater, Undersize Welds, Undercutting - Prepare surfaces and deposit additional weld material.
3. Excessive Weld Porosity, Incomplete Fusion - Remove unacceptable portions and reweld.

4. Cracks in Weld or Base Material - Determine the extent of the crack by use of magnetic particle or liquid penetrant examination. Remove the crack and sound material 2 in. beyond each end of the crack, and reweld.

E. The repaired weld shall be reexamined by the method originally used, and the same technique and quality acceptance criteria shall be applied.

16.0 POST WELD HEAT TREATMENT

Not applicable

17.0 ATTACHMENT WELDS

A. Attachment welds shall be performed in accordance with an approved WPS or WTS.

B. Materials used for welded attachments shall be compatible with the base material.

C. When applying attachments to materials of different thicknesses, the preheat requirements of the thicker material shall be observed.

D. When the specification requires temporary attachments to be removed, a method of removal that will not damage the base material shall be utilized; i.e., cut, grind, or saw the attachment off and grind the area flush. Grinding wheels that have been used on ferrous materials shall not be used on aluminum materials.

18.0 ATTACHMENTS

Attachment 1: Weld Profiles and Sizes