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Volume 2, WELDING FABRICATION PROCEDURE

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RECORD OF REVISIONS

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

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

WFP 2-12	<u>Welding POC/Committee</u>
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WFP 2-12 API 650, OIL STORAGE TANKS

1.0 PURPOSE AND SCOPE

1. This Welding Fabrication Procedure (WFP) shall govern the welding of components to the requirements of API 650 (Reference 1). The Code edition and addenda for this procedure shall be the latest in effect or as otherwise specified by the engineering specification.

2.0 REFERENCES

1. API 650, “Weld Steel Tanks for Oil Storage”
2. ASME Section IX, “Welding and Brazing Qualifications”

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* and Reference 2.

4.0 WELDING PREREQUISITES

- A. All welding shall comply with the requirements specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (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, dust, or high wind. The welder and weld joint shall be sufficiently protected from inclement conditions. 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. Preheating above the minimum temperature specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS) may be necessary to remove any entrapped moisture. The additional preheat should be applied if there is reason to believe moisture is present.

5.0 MATERIALS

- A. Base Materials
- B. Only the materials specified on the Non-Code WTS or a comparable ASME or AWS WPS may be welded using this procedure.
 1. Filler Materials
- C. Welding filler materials to be used with this procedure are specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS). A listing of applicable welding filler materials is provided in GWS 1-07, *Material Specifications*.
- D. Requirements for procurement and control of filler materials shall be in accordance with GWS 1-03, *Welding and Brazing Material Procurement and Control*

- E. Welding filler materials (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. The edges of plates may be sheared, machined, chipped, or machine oxygen cut. Shearing shall be limited to $\frac{3}{8}$ in. thickness of plates for butt-welded joints and $\frac{5}{8}$ in thickness for lap-welded joints. When edges of plates are oxygen cut, the resulting surface shall be uniform and smooth and shall be free of scale and slag accumulations before welding. Circumferential edges of roof and bottom plates may be manually oxygen cut. Kerf or gouge marks on the joint bevel deeper than 1/8" (0.125) 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, rust, scale, slag, grease, and other foreign s that are detrimental to welding.
- B. A fine film of rust adhered to the joint edges need not be removed prior to welding.
- C. Weld-through primers, e.g., Deoxaluminite, Spatter-weld, or Carboweld 11, need not be removed prior to welding.
 - 1. Solvents approved for use on the base material and weld materials are methyl alcohol, ethyl alcohol, isopropyl alcohol, acetone, methyl ethyl ketone, 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 GWS 1-06, Weld Joint Design. If the tolerances cannot be achieved, the end preparations may be built up by welding or re-prepped by machining or grinding.
- B. Plates to be joined by butt welding shall be matched accurately and retained in position during the welding operation (see paragraph 15.A.3).
- C. During the welding operation, plates shall be held in close contact at all lap joints.
- D. Shell plates may be aligned by metal clips attached to the bottom plates, and the shell may be tack-welded to the bottom before continuous welding is started between the bottom edge of the shell plate and the bottom plates.

9.0 PREHEAT

- A. When the base metal temperature is below the minimum preheat temperature specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS). The base metal shall be heated such that the surfaces to be welded are at or above the minimum preheat temperature prior to welding.
- B. The preheat temperature shall be maintained for a distance of at least 3 inches on each side of the weld joint and in advance of the welding. Preheat temperature above 125° F shall be checked by using a surface pyrometer, "Tempilstik," or non-mercury-type thermometer. Indicating crayons shall not be used directly in the weld zone.

10.0 TACK WELDS

- A. Tack welds shall be made by qualified welders in accordance with the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS).
- B. Defective tack welds shall be removed or repaired prior to welding.
- C. Tack welds used in the assembly of vertical joints of tank shells shall be removed and shall not remain in the finished joint when the joints are welded manually.
- D. Tack welds in the bottom, roof, and circumferential joints of the tank shell need not be removed provided they are sound and the subsequently applied weld beads are thoroughly fused into the tack welds.

11.0 BACKPURGE/BACKING GAS

Not applicable.

12.0 INTER-PASS TEMPERATURE

- A. Inter-pass temperature shall not exceed the maximum value specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS) and shall be checked on the surface of the component using a surface pyrometer, “Tempilstik,” or non-mercury-type thermometer. Indicating crayons shall not be used directly in the weld zone.
- B. If the temperature of the weld is above the maximum inter-pass temperature specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS) the weld shall be allowed to cool down below the maximum inter-pass temperature, but not below the minimum preheat temperature, prior to resumption of welding.

13.0 WELDING TECHNIQUE

- A. Welding voltage and amperage shall be in accordance with the limits specified on the Welding Technique Sheet. 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 WPA-approved equivalent) inspector using calibrated voltage and amp meters or approved welding parameter recording equipment.
- B. Cracks or blowholes that appear on the surface of a weld bead shall be removed by filing, grinding, chipping, or air carbon arc gouging before depositing the next bead. Oxygen gouging shall not be used on quenched and tempered steel.
- C. Before welding over previously deposited metal, all slag and flux shall be removed, and the weld and adjacent base material 1 inch on either side of the weld shall be brushed clean.
- D. For double-welded butt joints, before applying weld metal on the second side to be welded the root shall be prepared by suitable methods such as chipping, grinding, or air carbon arc gouging to assure sound metal.
- E. The recommended weld bead thickness shall be $\frac{1}{16}$ to $\frac{3}{16}$ inches. Passes shall be less than $\frac{1}{2}$ inch thick unless otherwise specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS).

- F. Peening may be used to control distortion or to relieve residual stresses. Peening shall not be performed until at least $\frac{3}{8}$ in. depth of bevel has been deposited. Peening shall not be applied to cover passes, base, or weld layers requiring nondestructive examination. Peening shall not be used to mask a defect.
- G. After being laid out and tacked, bottom plates shall be joined by welding the joints in the sequence provided in Attachment 2, unless otherwise specified by the engineer.
- H. All welding processes may be single pass or multiple passes per side unless otherwise specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS).
- I. Welding shall be performed single arc unless otherwise specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS).

14.0 INTERRUPTION OF WELDING

- A. Welding may be interrupted without restriction, unless otherwise specified in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS).

15.0 INSPECTOR QUALIFICATION

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

16.0 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 and except as noted in paragraph 15.A.2.
 - 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. Butt-welded joints to be radiographed shall be prepared as follows:
 - a. Weld ripples or weld surface irregularities on both the inside and outside shall be removed by any suitable mechanical process to such a degree that the radiographic contrast resulting from any irregularities cannot mask or be confused with the image of any objectionable defect. Machine or ground surface finishes shall not be less than 250 RMS.
 - b. The weld surface shall merge smoothly into the plate surface.
 - c. The finished surface of the weld reinforcement may be flush with the plate or may have a reasonable uniform reinforcement not to exceed the amount shown in Attachment 1.
 - 3. The misalignment of completed vertical butt joints of tank shells shall not exceed 10% of the plate thickness or $\frac{1}{16}$ inch, whichever is the larger.
 - 4. The upper plate in completed horizontal butt joints of tank shells shall not project beyond the face of the lower plate at any point by more than 20% of the thickness of the upper plate, with a maximum of $\frac{1}{8}$ inch except that a projection of $\frac{1}{16}$ inch is permissible for upper plates less than $\frac{5}{16}$ inch thick.

5. The edges of welds shall merge with the surface of the plate without a sharp angle. There shall be a maximum permissible undercut of $1/64$ inch of the base metal for vertical butt joints and $1/32$ inch for horizontal butt joints.
 6. The thickness of the reinforcement of the welds on butt joints on each side of the plate shall not exceed the amount shown in Attachment 1.
- 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.
 2. The surface condition of the finished welds shall be suitable for the proper interpretation of nondestructive examinations.

17.0 WELD REPAIRS

- A. Defects found in welds shall be called to the attention of the LANL Welding Program Administrator (WPA) or authorized alternate and approval obtained prior to repair. Completed repairs shall be subject to the approval of the LANL WPA or authorized alternate.
- B. Weld repairs shall be performed using the original Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS) or an approved alternate Welding Technique Sheet (WTS) to restore a weld to an acceptable condition.
- C. Pinhole leaks or porosity in tank-bottom joints or roof joints may be repaired by applying an additional weld bead over the defective area. Other defects or cracks in tank bottom joints shall be repaired in accordance with paragraph 16.D.
- D. Cracks and all defects in shell joints or shell to bottom joints shall be removed by chipping, grinding, machining, or air carbon arc gouging from one or both sides of the joint and re-welded.
- E. Repairs of defects discovered after the tank has been filled with water for test shall be made with the water level at least 12 inches below the point being repaired or with the tank empty if the repairs are on or near the tank bottom. Welding shall not be performed on any tank unless connecting lines have been completely blanked off.
- F. Welded repairs shall not be attempted on a tank filled with oil, or on a tank that has previously contained oil, until the tank has been emptied, cleaned, and freed of gas or oil residue in a safe manner. Repairs shall not be attempted on a tank that has contained oil, except in a manner approved in writing by the engineer and in the presence of the LANL WPA.

18.0 POST WELD HEAT TREATMENT

- A. Post weld heat treatment when indicated in the Welding Procedure Specification (WPS) or Welding Technique Sheets (WTS) shall be performed in accordance with GWS 1-08, Post Weld Heat Treatment GWS.

19.0 ATTACHMENT WELDS

- A. Bars, clamps, temporary attachments, etc. welded to the base material shall be the same P-number as the base material.

- B. When applying attachments to materials of different thicknesses, the preheat requirements of the thicker material shall govern.
- C. When the engineering specification requires removal of temporary attachments, a method that will not damage the base material shall be utilized, e.g. cut, grind, or air carbon arc gouge the attachment off and grind the area flush.

20.0 ATTACHMENTS

Attachment 1: Weld Reinforcement Table

Attachment 2: Recommended Sequence for Welding Seams Joining Bottom Plates