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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	IMP and 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 2-01	<u>Welding POC/Committee</u>
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WFP 2-01 ASME B31 SERIES PIPING CODES

1.0 PURPOSE AND SCOPE

- A. This Welding Fabrication Procedure (WFP), used in conjunction with the appropriate Welding Procedure Specification (WPS), shall govern the welding of piping to ASME B31 series requirements (see References 1-4). The Code edition and addenda for this procedure shall be the latest in effect or as otherwise specified by engineering requirements.

2.0 REFERENCES

1. ASME B31.1, "Power Piping"
2. ASME B31.1, "Process Piping"
3. ASME B31.8, "Gas Transmission and Distribution Piping"
4. ASME B31.9, "Building Services Piping"
5. 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.
- B. When welders are qualified under API 1104 to perform welding activities on compressor station piping, their qualifications shall be based on the destructive mechanical test requirements of API 1104. See GWS 1-05.

4.0 WELDING REQUIREMENTS

- A. All welding shall comply with this procedure and requirements of the associated WPS or Welding Technique Sheet (WTS), if applicable.
- 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 specified temperature on the WPS or WTS may be necessary to remove any entrapped moisture. The additional preheat should be applied if there is suspicion of moisture being present.

5.0 MATERIALS

- A. Base Materials
 1. Only the materials specified on the WPS or WTS may be welded using this procedure.

B. Welding 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 (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. Members to be joined may be cut to shape and size by machining, shearing, chipping, grinding, thermal cutting, or air carbon arc gouging. Thermal cutting or air carbon arc gouging prepared members shall be reasonably smooth and true and have all slag and deep kerf marks removed prior to welding. Gouge or kerf marks deeper than $\frac{1}{8}$ in. shall be repaired before fit-up and tack welding. Base materials joint bevels prepared using thermal cutting or air carbon arc gouging may require additional grinding prior to welding.
- B. Prior to thermal cutting or air carbon arc gouging on P5B or P6 material with chromium content greater than 3.0%, the preheat specified on the WPS or WTS shall be applied to the material.

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 materials, which are detrimental to welding. Weld-through primers (e.g., Deoxaluminite, Spatter-Weld, and Carboweld 11) need not be removed.
- B. 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

Note: for B31.8 requirements see Attachment 3

- A. Butt weld ends to be joined shall not have an internal misalignment exceeding $\frac{1}{16}$ in. Components with the wall extending internally greater than $\frac{1}{16}$ in. shall be trimmed so that adjoining internal surfaces are approximately flush. However, this trimming shall not result in a piping component wall thickness less than the minimum design thickness and the change in contour shall not exceed 30° (3:1 taper).
- B. The root opening and fit-up tolerances shall be as specified in the GWS 1-06, *Weld Joint Design*. If the tolerances cannot be achieved, end preparations may be built up by welding or re-prepared by machining or grinding.

- C. 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 $\frac{3}{16}$ in. If the separation is greater than $\frac{1}{16}$ in., the leg of the fillet weld shall be increased by the amount of separation. The degree of angle on the perpendicular member of the joint shall be as specified in engineering standards/documents or drawings.
- D. In assembly of socket weld joints, the pipe or tube shall be withdrawn a distance of approximately $\frac{1}{16}$ in. away from contact between the end of the pipe and the face of the shoulder of the socket. In sleeve-type joints without an internal shoulder, there shall be a distance of approximately $\frac{1}{8}$ in. between the butting ends of the pipe or tube. The butting ends shall be centered in the sleeve. The depth of insertion of pipe or tube within the socket or sleeve shall not be less than $\frac{1}{4}$ in. **Note:** Gap inserts (Gapalets or equivalent) and approved shims may be used with prior approval from the Design Engineer or LANL WPA.

9.0 PREHEAT

- A. When the base material temperature is below the minimum preheat temperature specified in the WPS or WTS, the base material 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 in. on each side of the weld joint and in advance of the welding.
- C. Preheat temperature above 125 °F shall be checked by using a calibrated surface pyrometer, “Tempilstiks,” or nonmercury-type thermometer. Temperature 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 an approved WPS or WTS if applicable.
- B. Acceptable tack welds may be incorporated into the final weld.
- C. Defective tack welds shall be removed or repaired prior to welding.
- D. For GTAW tack welds on consumable inserts, the insert shall not be totally consumed at the point of the tack weld (button), no purge is required, and cracks in tack welds on consumable inserts shall be re-fused prior to making the root weld.

11.0 PURGE/BACKING GAS

- A. The WPS or WTS shall specify the required purge gas and any special requirements. For argon, the inlet shall be at the bottom and the outlet vent at the top. When required a calibrated oxygen analyzer shall be used to determine oxygen content prior to tack welding or root pass welding.
- B. When a gas purge or gas backing is specified in the WPS or WTS if applicable, the oxygen content of the gas exiting from the purge vent shall be less than 2% prior to welding. This shall be measured using one of the following types of oxygen analyzers or an equivalent:
 - Mine Safety Appliance MSA Type E
 - Johnson & Williams Model K
 - Honeywell Corporation Model K-4015.

Note: Flame-type (matches, wood or paper) devices are not an equivalent method of analyzing the oxygen content and shall not be used.

- C. When purge gas is required for groove welds, it shall be maintained for $\frac{3}{16}$ in. or three layers of weld.
- D. For socket welds, purge gas is not required unless the WPS or WTS identifies a purge gas type and the thickness of the pipe is less than 0.109 in.
- E. For weld joints using a consumable insert, the purge gas flow shall be approximately static and the use of an inclined manometer is recommended with pressure maintained at 0.5 inches maximum until the insert has been completely fused for the entire root circumference.

12.0 INTERPASS TEMPERATURE (IPT)

- A. Inter-pass temperature 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, “Tempilstiks,” 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 inter-pass 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.

13.0 WELDING TECHNIQUE

- A. Welding voltage and amperage should be in accordance with the limits specified on the WPS or WTS as applicable. Voltage ranges (for SMAW and GTAW) are a function of arc gap and are not mandatory settings for ASME Section IX purposes. 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 filing, grinding, chipping, or air carbon arc gouging before depositing the next bead. Oxygen gouging shall not be used on quenched and tempered steel, stainless steel, or Inconel materials.
- C. Before welding over previously deposited material, all slag and flux shall be removed, and the weld and adjacent base material 1 in. 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, or air carbon gouging to ensure sound material.
- E. Recommended bead thickness shall be $\frac{1}{16}$ inch to $\frac{3}{16}$ inch. All passes shall be less than $\frac{1}{2}$ in. thick unless otherwise specified in the WPS or WTS.
- F. Unless otherwise specified on the WPS or WTS, consumable inserts, root retainers, trailing shielding gas, and pulsing current shall not be used.

- G. Peening of P1 materials may be used to control distortion or to relieve residual stresses. Peening shall not be performed until 3/8 in. 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.
- H. All welding processes may be single pass or multiple passes per side unless otherwise specified in the WPS or WTS. Socket welds shall have a minimum of two weld passes, with the exception that two passes are not required for socket welds on pipe NPS 1 or smaller.
- I. Welding shall be performed by the single arc method unless otherwise specified on the WPS or WTS.

14.0 INTERRUPTION OF WELDING

- A. Definition - Interruption of welding means dropping from preheat temperature to ambient temperature prior to completion of welding or performing PWHT.
- B. Welding on P3, P4, P5A, and P5C materials with a maximum chromium content of 3.0% may be interrupted and the weld may be allowed to cool prior to post weld heat treatment, provided the following conditions are satisfied:
 - 1. A minimum of $\frac{3}{8}$ in. thickness of weld is deposited or 25% of the welding groove is filled, whichever is greater
 - 2. The weld is allowed to cool slowly to ambient temperature.
 - 3. The weld has been visually examined by a CWI or qualified equivalent to ensure that no cracks have occurred before welding is resumed, and
 - 4. The required preheat has been applied before any welding is resumed.
- C. Field welding of P5B, P6, or P7 materials requires special care to assure the desired weld properties are achieved and maintained throughout the welding process. Interruption of in-process welding on P5B P6, or P7 materials should be controlled and limited as a non-routine practice. When necessary, welding on P5B, P6, or P7 materials may be interrupted before completion and the weld may be allowed to cool prior to post weld heat treatment, provided the following conditions are satisfied:
 - 1. A minimum of $\frac{1}{2}$ in. thickness of weld is deposited or $\frac{2}{3}$ of the welding groove is filled, whichever is greater
 - 2. A temperature of $450\text{ }^{\circ}\text{F} \pm 50\text{ }^{\circ}\text{F}$ is maintained for 1 hour after welding and the weld joint is then allowed to cool slowly to ambient temperature
 - 3. The weld has been visually examined to ensure that no cracks have occurred before welding is resumed, and
 - 4. The required preheat has been applied before any welding is resumed.

Note: Upon completion of welding on P5B P6, or P7 materials the preheat temperature should be maintained for 1 hour and the weld joint then allowed to cool slowly to ambient temperature. Alternatively, the preheat temperature may be maintained until initiation of PWHT.
- D. Welding on other materials may be interrupted without restriction, unless otherwise specified in WPS or 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 WELD REPAIRS

- A. Weld repairs shall be performed using the original WPS or an alternate WPS, or WTS developed for each specific repair to restore a weld to an acceptable condition.
- B. Unacceptable defects shall be removed by chipping, grinding, machining, or air carbon arc gouging. Prior to air carbon arc gouging on P1 Group 3, P3, P4, P5A, P5B, P5C, or P6 materials with chromium content greater than 3.0%, the preheat specified on the WPS shall be applied to the material.

17.0 POST WELD HEAT TREATMENT

- A. Post weld heat treatment, when indicated on the WPS, or WTS shall be performed in accordance with the GWS 1-08, *Post Weld Heat Treatment*.
- B. The nominal thickness for determining whether PWHT is required is the lesser of the weld thickness or the thicker of the materials being joined. For groove welds, the weld thickness is the thicker of the two abutting ends after weld preparation, including inside diameter machining. For fillet welds, the weld thickness is the throat thickness. For partial penetration welds, the weld thickness is the depth of the weld groove, and for repair welds, the weld thickness is the depth of the cavity.
- C. For welds joining materials of different P numbers, the PWHT requirements of the material with the higher PWHT temperature shall govern, unless exemptions apply to the higher material. The lower transformation or transition temperature shall not be exceeded for either material. When welding non-pressure part to pressure parts, the PWHT temperature shall not exceed the maximum temperature acceptable for the pressure part.
- D. Above 600 °F the rate of heating and cooling shall not exceed 600 °F per hour divided by ½ the maximum thickness of the material at the weld. In no case shall the rate exceed 600 °F per hour. The WPS may further restrict PWHT heating and cooling rate requirements.

18.0 ATTACHMENT WELDS

- A. Bars, clamps, temporary attachments, etc, welded to the base material shall be the same P number material as the base material, however, P1 attachments may be used on P1, P3, P4, P5A, P5B, or P5C materials. Attachment welds shall be performed in accordance with an approved WPS or WTS.
- B. When applying attachments to materials of different thicknesses, observe the preheat requirements of the thicker materials.
- C. When the specification requires a temporary attachment to be removed, 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. Over-grinding or gouges in the surface shall be repaired using the same WPS or a WTS developed for specifically for repairs.

19.0 ATTACHMENTS

Attachment 1: ASME B31.1, Weld Acceptance Criteria

Attachment 2: ASME B31.3, Weld Acceptance Criteria

Attachment 3: ASME B31.8, Weld Joint Fit-up and Weld Acceptance Criteria

Attachment 4: ASME B31.9, Weld Acceptance Criteria