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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	Administrative changes only. Organization updates from LANS transition. 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 2-03	<u>Welding POC/Committee</u>
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WFP 2-03 API 1104 WELDING OF PIPELINES & RELATED FACILITIES

1.0 PURPOSE AND SCOPE

- A. This welding fabrication procedure (WFP) governs the welding of piping to API-1104 requirements. 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. API 1104, “Welding of Pipelines and Related Facilities”

3.0 WELDER QUALIFICATION

- A. Welder/welding operators shall be currently certified by having performed qualification tests in accordance with GWS 1-05, *Welder Performance Qualification/Certification*; API-1104; and as detailed in this WFP.
- B. Section 6 of Reference 1 and GWS 1.05 contain unique specific requirements regarding the type and number of test specimens required for the performance qualification of welders. These requirements shall be consulted to ensure that the type and number of specimens selected for the specific welder performance test met the applicable requirements.
- C. LANL WPA may, in lieu of destructive testing for welder or welding operator qualifications of butt welds, choose to perform radiographic examination in accordance with Section 6.6 of Reference 1.
- D. Use of automatic welding processes with filler material shall have each unit and operator qualified in accordance with Section 12 of Reference 1.
- E. Use of automatic welding processes without filler metal shall have each unit and operator qualified in accordance with Section 13 of Reference 1.

4.0 WELDING REQUIREMENTS

- A. All welding shall comply with this procedure and requirements of the associated WPS or WTS, as applicable.
- B. No welding will be performed when the ambient temperature in the immediate vicinity of the weld is lower than 0 °F (-18 °C), when the prevailing weather conditions, including but not limited to blowing sands, or when surfaces are wet or exposed to rain, snow, or high winds. Enclosures shall be erected when necessary to protect the welder and items being welded.
- C. When pipe is welded above ground, the working clearance shall not be less than 16 in. (400 mm). When the pipe is welded in the trench, the bell hole shall be large enough to provide accessibility for welding and inspection personnel and equipment.

5.0 MATERIALS

- A. Base Materials
 - 1. Only the materials specified on the WPS or WTS may be welded using this procedure.
 - 2. The range of diameters and wall thicknesses of the materials over which the procedure is

applicable is identified in the WPS or WTS.

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. With the exception of flash butt welding process that does not require filler material, welding filler materials specified in the WPS or WTS (electrodes, bare filler wire, and or consumable inserts) shall be utilized with this procedure.

6.0 BASE MATERIAL JOINT PREPARATION

- A. Members to be joined may be cut to shape and size by machining, grinding, or machine oxygen cutting. If authorized by the engineer, manual oxygen cutting may also be used. When employed, manual or machine oxygen cutting prepared surfaces shall be reasonably smooth and true and have all surface slag and deep kerf marks removed prior to welding. Kerf marks deeper than 1/8" shall be repaired prior to fit-up and tack welding. Base material beveled joints may require grinding prior to welding to remove any surface slag or surface imperfections

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 cleaning of the base materials 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 alignment of abutting ends shall minimize the offset between the surfaces of the abutting pipe ends. For pipe ends of the same nominal thickness, the offset should not exceed $\frac{1}{8}$ in. However larger variations are permissible provided the variation is caused by variation of the pipe end dimension within the manufacturer's tolerances, such variation has been distributed uniformly around the circumference of the pipe, and is not less than a 3-to-1 taper (hi-low) angle.
- B. The root opening and fit-up tolerances shall be as specified in GWS 1-06, *Weld Joint Design*. If the tolerances cannot be achieved, appropriate LANL or (SSS as applicable) supervision or engineering shall be notified and resolution received prior to start of welding activities.

9.0 PREHEAT

- A. Base materials to be welded shall be preheated to the minimum temperature indicated in the Welding WPS or WTS, as applicable.
- B. The minimum 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. When preheat temperatures are above 125°F the temperature should be checked, within 1 in. on either side of the weld joint, by using a surface pyrometer, manual temperature indicating crayons, or non mercury-type thermometer. Crayon residue shall be removed prior to resuming welding, if located within the welding area.

10.0 TACK WELDS

- A. Tack welds shall be made by qualified welders in accordance with an approved WPS or WTS, as applicable.

11.0 PURGE/BACKING GAS

- A. The Welding 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.
- B. When purge gas is specified on the WTS, 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 (calibrated) 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 devices (matches, wood or paper) are not an equivalent method of analyzing the oxygen content and shall not be used.

- C. When purge gas is required, it shall be maintained for a minimum of $\frac{3}{16}$ in. or three layers of weld.
- D. For socket welds, purge gas is not required unless the Welding Procedure Specification (WPS) or Welding Technique Sheet (WTS) identifies a purge gas type and the thickness of the pipe is less than 0.109 in. (3 mm).
- 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 INTER-PASS TEMPERATURE (IPT)

- A. The minimum or maximum inter-pass temperature (IPT) requirements shall be detailed in the WPS or WTS.
- B. The inter-pass temperature shall not be less than the minimum preheat or exceed the maximum temperature specified in the WPS or WTS.

13.0 WELDING TECHNIQUE

- A. Current polarity, voltage, and amperage shall be in accordance with the limits specified on the WPS or WTS, as applicable. Voltage ranges are a function of arc gap and are not a mandatory setting. 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. For Oxygen Fuel Welding (OFW), the WPS or WTS, as applicable shall designate whether a neutral, carbonizing, or oxidizing flame is required. The size of the orifice in the torch tip (for each size wire or rod) shall be specified in the WPS or WTS, as applicable.
- C. The WPS or WTS determines the welding positions such as rolled or fixed.
- D. Defects that appear on the surface of a weld bead may be removed by filing, grinding, chipping, or air carbon arc gouging before depositing the next weld layer.
- E. Before welding over previously deposited metal, all slag and flux shall be removed, and the weld and adjacent 1/2 in. on each side of the base material shall be brushed clean.
- F. Either power tools or hand tools may be used for cleaning or grinding of base material between weld passes and after completion of the cover-pass.

14.0 INTERRUPTION OF WELDING

- A. The maximum time between the completion of the root pass and the start of the second pass shall be as detailed in the WPS or WTS, as applicable.
- B. Welding may be stopped for the night or other reasons only after the completion of the second or subsequent passes.
- C. Welding may be resumed provided the required preheat has been applied in accordance with the WPS or WTS, as applicable.

15.0 INSPECTOR QUALIFICATION

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

16.0 ACCEPTANCE CRITERIA FOR COMPLETED WELDS

- A. Butt Welds
 - 1. WPA-approved LANL personnel (AWS-CWI or equivalent) shall have the right to inspect all welds or subject them to mechanical test. Visual examination may be performed during welding or after the welds have been completed. The frequency of visual examinations or other NDE methods shall be as specified in the engineering procurement or installation specification.
 - 2. Cracks of any size or location or star/shallow crater cracks exceeding 5/32 in. shall be repaired.

Note: Shallow crater cracks or star cracks are located at stopping points of a weld pass and are the result of weld metal contraction or shrinkage during solidification.

- 3. When visual and mechanical means are used to determine the depth, undercutting adjacent to the cover pass or root pass shall not exceed the following dimensions:

Depth	Length
1/32 in. or 12.5% of pipe wall, whichever is smaller	Not Acceptable
1/64 in. or > 6%-12.5% of pipe wall,	2 in. in continuous 12 in. weld length or 1/6 the

whichever is smaller	weld length, whichever is smaller
$< 1/64$ in. or 6% of pipe wall thickness	Acceptable, regardless of length

4. The quality of welds may also be examined by approved nondestructive examination (NDE) methods. The NDE method may consist of radiography, magnetic particle, liquid penetrant, ultrasonic, or other acceptable NDE method.
5. The welds shall be evaluated on the basis of Section 9 of Reference 2.1 or at LANL WPA option, Appendix A of Reference 2.1. In the latter case, more extensive inspection activities are necessary to determine the imperfection size.
6. The as-welded surface condition of the finished welds shall be suitable for visual examination or 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.

B. Socket and Fillet Welds

1. The as-welded surface condition of the finished welds shall be suitable for visual examination or the proper interpretation of nondestructive examinations, where required. In the case where there is question regarding the surface condition for inspection evaluation the surface shall be prepared to the satisfaction of LANL inspection personnel (CWI or equivalent). Undercut at either toe of each fillet leg shall not be more than the limits for butt welds in paragraph (table) 16.1.3.

C. Automatic Welding

1. During automatic flash butt welding sequence, the welder shall monitor the electrical and mechanical procedure parameters of the welding machine on the appropriate strip chart. If the welding parameters exceed tolerance or if the strip chart is found unacceptable after welding the weld shall be rejected and repaired as directed by authorized supervision or LANL representative.
2. For flash butt welding activities, the inside diameter weld reinforcement shall not be raised above the parent metal material by more than $1/16$ in. The outside diameter weld reinforcement shall not be raised above the parent metal by more than $1/8$ in.
3. If during visual examination of flash butt welds any single defect exceeds $1/8$ in or the aggregated length in any continuous 12 in. length of weld exceeds $1/2$ in. the weld shall be removed.
4. Automatic welding with filler metal shall be examined in accordance with Section 8 of Reference 1.

17.0 WELD REPAIRS

- A. Weld repairs shall be performed using the original WPS or WTS an alternate approved repair WPS or, as applicable, to restore a weld to an acceptable condition.
- B. When a Weld Repair Technique Sheet is required, the procedure shall be established and qualified to demonstrate that a weld with suitable mechanical properties and soundness can be produced. The repair procedure shall contain as a minimum the following elements.
 - Method of defect exploration
 - Method of defect removal
 - Examination of repair excavation area to confirm complete defect removal
 - Preheat and interpass temperature requirements
 - Welding process and techniques
 - Any special NDE requirements
- C. Repairs shall be inspected and accepted by the same examination method used to examine the original weld.

18.0 POST WELD HEAT TREATMENT

- A. Post weld heat treatment is required of material when the wall thickness exceeds the minimum, as indicated on the WPS and shall be performed in accordance with GWS 1-08, *Post Weld Heat Treatment*.
- B. The method 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.
- C. Completed flash butt welds shall be heated after welding to a temperature above the lower transformation temperature in accordance with the WPS followed by either controlled cooling or still ambient air cooling. The heat treatment cycle shall be documented using a calibrated strip chart recorder.

19.0 ATTACHMENT WELDS

- A. Bars, clamps, temporary attachments, etc, welded to the base material shall be the same P-number material as the base material. Attachment welds shall be performed in accordance with an approved WPS or WTS, as applicable.
- B. When the temporary attachment is 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 an approved repair WTS.

20.0 ATTACHMENTS

None.