SECTION 18310
PIPE WELDING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Requirements applicable to on-site welding of pipe and stainless steel liner slate in the Target Building and Beam Dumps.

1.2 RELATED SECTIONS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

B. Section 18100, General Welding Requirements.

C. Section 18350, Pipe Welding Procedure Specifications.

PART 2 - PRODUCTS

2.1 BASE MATERIAL

A. Weld only materials identified in the design document and on each WPS by reference to P-numbers as listed in ASME Sect. IX, QW 422.

2.2 WELDING MATERIALS AND FILLER METALS

A. Store, handle, and identify welding electrodes and consumables at all times to avoid material degradation and ensure they are identifiable as acceptable material until the material is actually consumed in the process.

2.3 WELDING GAS

A. Use welding grade gasses and mixtures with a dew point of -40^{o}F or lower for welding, including purging.

PART 3 - EXECUTION

3.1 WELDING PROCEDURE QUALIFICATION RECORDS

A. Supporting PQRs are listed on each WPS.

3.2 WELDER AND WELDING OPERATOR PERFORMANCE QUALIFICATION

A. Use welders or welding operators qualified in accordance with the requirements of Section 18100. Additional welder training (mock-ups) should be considered when welding in areas of restricted accessibility or other unusual conditions.

3.3 BASE MATERIAL PREPARATION

A. Materials may be prepared by machining, grinding, arc-gouging, plasma, laser, burring, filing, chipping, shearing, or flame cutting, or combinations of these methods. Flame cutting is permitted only on P1, P3, P4, P5, P10, and P11 materials.

B. When arc-gouging, plasma, or flame-cutting methods are used, remove slag, dross, and excess oxidized metal from weld surfaces prior to welding. Taper notches uniformly into the surrounding surfaces to allow welding to be completed in an acceptable manner. Discoloration resulting from these operations is not considered to be harmful oxidation and may be accepted without additional surface conditioning.

C. Preheat materials, other than P-l, which are prepared by carbon arc-gouging, plasma, or flame-cutting methods in accordance with the preheating requirements of an applicable WPS. For P-l materials, the preheat requirements of the WPS are recommended for thermal-cutting operations. In addition, for P4 and P5 material classifications, condition the weld preparation surface by removing a minimum of l/32 in. by mechanical means.

D. Immediately prior to and during welding, remove paint, oil, rust, scale, water, or other material that is detrimental to the welding operation.

E. Use low halogen-type grinding wheels, wire brushes, flapper wheels, tapes, and cleaning fluids for the fabrication of P8 materials.

F. Use low sulphur-type grinding wheels, wire brushes, flapper wheels, tapes, and cleaning fluids for the fabrication of nickel base alloys.

3.4 WELD JOINT DETAIL DRAWINGS

A. Do not use welded miter bends unless specified on design drawings.

3.5 BACKING RINGS

A. Do not use backing rings unless specified on the drawings. When required, use backing rings of the size, type, and material specified.

B. Fit split backing rings to the pipe and double weld the opening to provide complete weld penetration prior to joint welding of the pipe components.

C. Unless permitted by the WPS, do not use nonmetallic retainers or nonfusing metallic retainers (backings) without prior approval by the Construction Manager.

3.6 ALIGNMENT FIT-UP TOLERANCE

A. For socket weld fit-ups, allow approximately 1/l6 in. withdrawal between the pipe end and the mating edge on the socket weld fitting prior to welding.

3.7 WELDING REQUIREMENTS

A. Make copies of this section and the applicable WPS available for ready reference to the welders or welding operators and quality control.

B. Welding is not permitted when there is impingement of rain, snow, sleet, or high wind in the weld area.

C. Tack Welds and Temporary Attachments:
   1. Use qualified welders to weld tack welds and temporary attachments (including fit-up lugs) in accordance with all of the requirements of the WPS assigned to weld the joint. Inspect tack welds for defects. If found to be defective, remove the defects.
   2. When tack welds are deposited in weld grooves in order to secure alignment, either remove completely when they have served their purpose, or prepare the tacks' starting and stopping ends for incorporation into the final weld.

3. Do not weld carbon or low-alloy steel temporary attachments directly to austenitic stainless steel or high-nickel alloy components. First overlay the attachment with weld metal of a composition similar to the component at the point of attachment. Then weld to the component with electrodes of a composition similar to the component.
4. Dress smooth and visually examine the area from which attachments have been removed.

D. Weld Joint Fit-up:
1. When necessary to achieve an acceptable joint fit-up, perform the following operations making sure to maintain the minimum required thickness, including mechanical, corrosion, and erosion allowances:
   a. Deposit weld metal on either the inside or outside surface to maintain minimum wall thickness or achieve fit-up. Taper weld buildup away from the weld joint at a 3-to-1 length to offset taper prior to examination. Perform the buildup in accordance with Items d 1) through 5) below. Examine the area to the criteria for the final weld.
   b. Grind, bore, or taper bore the pipe end as required, assuring that minimum wall thickness is maintained. Prepare the tapered end to a minimum 3-to-1 length to offset taper prior to examination. In addition, examine the ground, bored, or taper bored areas to the standards for the base material.
   c. Weld joints with backing and root openings exceeding 3/8 in. as follows. In each layer, deposit the first beads on the weld edges so as to reduce the shrinkage resulting from tying the two sides together. A cascading or shingling technique may also be used.
   d. For open butt joints in which the inside root surface is accessible for visual examination, the final joint is radiographed or the joint is double welded.
      1) Limit buildup of joint surfaces to 3/8 in. thickness on each joint edge without the approval of the engineer and shall be as follows.
      2) Perform buildup using one of the WPSs applicable to the weld joint and welders qualified for the welding procedure selected.
      3) Contour the completed buildup as nearly as possible to the dimensional requirements of the original weld edge preparation.
      4) Visually examine the completed buildup.
      5) For weld joints requiring radiographic examination, radiography of the buildup may be performed either prior to or after welding the joint.
   e. For open butt joints not requiring radiography and not accessible for visual examination from the backside, limit the buildup to correct oversize root openings to 3/8 in. thickness on each joint edge without the approval of the engineer. Build up and contour the buildup prior to final fitup in accordance with para. C above.

E. Interpass Cleaning:
1. Prior to deposition of succeeding weld passes, remove the slag, flux, weld craters, and excessive weld spatter from the weld and adjacent weld preparation or base material by grinding, chipping, wire brushing (hand or power), or deslagging tools to the extent that the conditions will not be detrimental to deposition of sound weld metal.
2. Do not weld over defective weld metal. Remove cracks and areas lacking fusion prior to deposition of additional weld metal.

F. String or Weave Bead Technique:
1. Use a minimum weave technique or stringer bead technique to the maximum extent possible.
2. Limit weaving so that the weld bead width is equal to or less than specified in the following paragraphs unless otherwise specified on the WPS.
   a. SMAW:
      1) Six times the electrode core wire diameter for F3 and F4 filler metal (E6010, E7018, etc.).

2) Four times the electrode core wire diameter for F5 filler metal (E308-16, etc.).
3) Three times the electrode core-wire diameter for F4X filler metal (ENiCrFe-3, etc.).

b. GMAW and FCAW:
1) When the root opening is 1/2 in. or greater, use a multipass, split-layer technique. Also, use the split-layer technique in making multipass welds when the width of the layer exceeds 5/8 in. as detailed in Item e below.

c. Manual GTAW - four times the filler wire diameter.

d. For machine/automatic welding, specify width, frequency, and dwell time of oscillation on the applicable WPS, job specification, or technique sheet.

e. For the SMAW and GMAW processes, for joints where the root openings or welding gap exceeds 3/8 in., weld the joint as follows: In each layer, deposit the first beads on the weld edges so as to reduce the shrinkage resulting from tying the two sides together. A cascading or shingling technique may also be used.

G. Peen welds to written instructions when approved by the Construction Manager.

H. Use filler metal for welding with the GTAW process (unless otherwise specified on the WPS). Consumable inserts are considered filler material. Wash passes without the use of filler metal are not allowed.

I. Make welds which become inaccessible because of the fabrication sequence available upon completion to the inspector's satisfaction prior to the weld being made inaccessible.

J. Do not use the SM, GM (flux or alloy cored), and SA processes for root pass-welding of wetted crevice joints (socket joints or joints with permanent backing) in stainless steel without the engineer's approval for specific applications.

K. Seal welds of threaded joints:
1. The preferred method is to remove exposed threads prior to welding.
2. Covering all exposed threads with weld metal is an acceptable alternate.

3.8 PROCESS DEPOSIT THICKNESSES

A. In WPSs for open butt welding with more than one welding process, such as a gas tungsten arc root and shielded metal arc remainder the words "root" or "root pass" used for an increment of weld, means a minimum of the first two layers of the weld (approximately 3/16 in.) and a maximum of 3/8 in. thickness of deposited weld metal. Each layer of the weld may consist of one or more weld beads laid side by side. The "remainder" or "rem" is the portion of the weld not included in the "root" or "root pass." These definitions are not standard American Welding Society A3.0 definitions.

3.9 PREHEAT/INTERPASS FOR WELDING

A. Apply preheat for welding by flame, induction, or resistance methods. Remove soot formed on stainless steel material as a result of flame heating as soon as practicable after removal of the heat source.

B. When heating with an oxyacetylene flame, use a neutral flame and constantly move the flame about the entire weld joint.

C. Do not exceed the interpass temperature of the applicable WPS.

D. Measure preheat temperatures by temperature indicating crayons, contact pyrometers (digital or analog), infrared thermometers, optical pyrometers, or thermocouples. Do not use low-melting

metallic alloys. Apply temperature-indicating crayon measurements to the surfaces adjacent to the weld joint, using low-halogen type for stainless steel and low-sulphur type for nickel alloys.

E. Maintain the minimum preheat specified for a minimum distance of 3 in. from the weld preparation during welding operations.

F. In multipass welds, check the maximum interpass temperature prior to the start of each weld pass, at the edge of the weld.

3.10 PURGING REQUIREMENTS

A. Purge, when required by the WPS, during welding until a minimum of 3/16 in. of weld metal has been deposited. Analyze the exit gas for no more than 1% oxygen. If the exit gas cannot be analyzed, maintain the purge for six volume changes of the purge volume prior to welding. Purge gas flow rate may be increased during the preweld purge period and reduced during the tacking and welding operation to a minimum positive pressure. During tacking and welding, purge at the rate indicated on the WPS. Provide an exit so that pressure cannot build up during the welding operation.

B. The following table satisfies the six volume changes requirement and may be used as a guide for purge rates and time for the pipe sizes listed:

Table 1

Nominal pipe size (in.)	Purge time (min/ft)	Purge flow rate (min)	Vent size (min)(in.)
2 1/2	1 1/2	25 cfh	1/8
3	1 1/2	25 cfh	1/8
3 1/2	2	25 cfh	1/8
4	2	25 cfh	1/8
5	3	25 cfh	1/8
6	4	25 cfh	1/8
8	6	25 cfh	1/8
10	10	25 cfh	1/8
12	12	25 cfh	1/8
14	14	25 cfh	1/8
16	16	25 cfh	1/8
18	18	25 cfh	1/8
20	20	25 cfh	1/8

C. Construct purge dams of wood, metal, rubber, plastic, or water-soluble paper. Purge dams constructed of material other than water-soluble paper shall be readily retrievable.

D. Construct paper purge dams of "Dissolvo Paper." Use only "Elmer's School Glue" or "Dissolvo WAT-N-Tape" to attach sheets of Dissolvo Paper together and to hold the dams in place in the pipe.

1. Do not use water-soluble purge dams in systems which do not receive a subsequent system hydro or water flush.
2. Locate water-soluble purge dams in an area which will not be heated to more than 300 deg F during welding and PWHT. A spacing of 6 in. from the edge of the weld to the

purge dam should normally ensure satisfactory purge dam integrity when preheat and PWHT are not involved.

E. Use shielding/purging gas flowmeters designed for the type of gas used.

F. Weld root purge may be omitted from a WPS when making:
1. Backing strip welds.
2. Fillet and partial penetration welds.
3. Double-welded joints which are backgouged or background before welding the second side.
4. Socket welds in material with a thickness not less than 3/16 in.
5. Repair welds in materials (including welds) in which the remaining material thickness after excavation is not less than 3/16 in.

G. Unless otherwise specified on the WPS, do not use trailing gas.

3.11 WELD REINFORCEMENT

A. See Attachment A.

3.12 POSTWELD HEAT TREATMENT

A. Perform PWHT when required by the WPS in accordance with detail written procedures.

3.13 REPAIRS BY WELDING

A. Repair or replace a weld having one or more defects (imperfections of a type or magnitude exceeding the acceptance criteria specified). Reexamine the new work by the same methods, to the same extent, and by the same acceptance criteria as required for the original weld.

B. In-process interbead cleaning of welds to remove surface roughness, excess reinforcement, weld spatter, slag, visible porosity, undercut, crater cracks, and overlap detected by the welder during welding is not considered repairs.

C. Major repairs require the concurrence of the Construction Manager before proceeding with the repair. Major repairs are defined to be the weld repair of large cracks other than crater cracks or recurring defects, both being indications of welding process or material problems.

D. Make excavations of areas being repaired or reworked of sufficient size and dimensions to remove defects and allow accessibility for welding. Do not create sharp corners or undercut the sidewalls. Contour the sides of the excavation uniformly with the adjacent base material sufficiently to allow repair welding.

3.14 IN-PROCESS MONITOR

A. The Facilities Manager, CM, or Contractor monitors their own in-process welding to ensure completed welds will meet the requirements of this section, Section 18100, and contract requirements. Include the following in the monitoring activity:
1. Preweld.
a. Proper material.
b. Weld joint dimensions (fit-up).
c. Alignment.
d. Surface cleanliness.
e. Qualified welder.
f. Proper procedure.
g. Proper filler metal.

2. During Welding.
    a. Procedure adherence.
    b. Workmanship.

B. Inspect and examine welds to the requirements of Section 18100. The visual acceptance criteria for welds is included in Attachment A.

3.15 WELDING DOCUMENTATION

A. Documentation requirements are in accordance with Section 18100.

ATTACHMENT A

PIPING VISUAL EXAMINATION ACCEPTANCE CRITERIA

Visually examine welds requiring inspection/examination after welding for compliance with the applicable welding procedures, drawings, and the requirements of this specification for at least the following items:

A.1 Weld Defects

Cracks, lack of fusion, overlap, undercut in excess of para. A.5, incomplete penetration in excess of para. A.3 (when full penetration is required), slag, porosity, weld spatter, and arc strikes are unacceptable in welds and adjacent base metal. Remove arc strikes and visually examine the area for defects and for evidence of thinning below the minimum material thickness. For alloy steel (P3, P4, P5) acid-etch the arc strike removal area to ensure removal of the heat affected zone.

A.2 Contour and Finish of Outside Surface of Welds

A.2.1 Remove as necessary coarse ripples, grooves, abrupt ridges, and valleys to perform other nondestructive tests without masking possible discontinuities.

A.2.2 If grinding has been performed for surface finishing operations, examine the weld and adjacent surfaces for thinning to below minimum design thickness.

A.2.3 When components of different outside diameters, offset ends, or of different thicknesses are welded together, provide a gradual transition between the two surfaces. The length of the transition may include the weld. The slope of the transition shall have a length-to-offset ratio of not less than 3 to 1 (see Fig. A.2.3). The slope may be determined prior to welding.

A.2.4 Overlap, which is defined as weld metal which protrudes beyond the toe of the weld, is unacceptable. See Fig. A.2.4.

A.3 Contour, Finish, and Penetration of Inside Surface of Welds When Accessible

A.3.1 Weld root concavity which reduces material below nominal wall thickness is not acceptable. Weld reinforcement may be considered as wall thickness of the material in such cases.

A.3.2 Inside surfaces of welds may generally be considered accessible when the weld is within two (2) pipe diameters of the open end. For pipe sizes 30 in. and greater, most weld roots should be considered accessible. Welds within the boundaries described above which can be examined with commonly available inspection tools (small inspection mirror and flashlight) should be examined to the extent possible.

A.3.3 Incomplete Penetration

The depth of incomplete penetration shall not exceed 1/32 in. or 0.2 times the nominal wall thickness, whichever is less. The length of incomplete penetration shall not exceed 1.5 in. in any 6 in. length of weld. For welds less than 6 in. long, the length of incomplete penetration shall not exceed 1/4 of the length. Tightly butted unfused root faces are unacceptable.

A.3.4 Internal Reinforcement

The limits for the internal reinforcement are the same as the external reinforcement in para. A.5.

A.4 Undercutting

Undercut exceeding 1/32 in. or 1/4 of the nominal wall thickness, whichever is less, is unacceptable.

A.5 Reinforcement

The height of reinforcement or internal protrusion exceeding the value shown in the table below is unacceptable. Blend weld metal smoothly into the component surfaces.

Nominal wall (in.)	Maximum reinforcement (in.)
≤1/4	1/16
>1/4 and ≤1/2	1/8
>1/2 and ≤1	5/32
>1	3/16

For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components. For fillet welds, height is measured from the theoretical throat.

A.6 Fillet, Socket, and Flange Welds

A.6.1 Fillet welds may vary from convex to concave provided that the size meets minimum requirements (see Fig. A.6.1).

A.7 Seal Welds on Threaded Joints
Exposed threads not covered with weld metal is unacceptable.

A.8 Removal of Purge Dams
When purge dams are used, verify purge dam removal or indicate the use of water soluble purge dams.

A.9 Length and Location
Verify the length and location of welds is as required by the specification, drawing, or welding procedure specification.

END OF SECTION 18310