WELDING PROCEDURE SPECIFICATION

MANUAL GAS TUNGSTEN ARC (DC) AND SEMIAUTOMATIC GAS METAL ARC WELDING OF 6XXX ALUMINUM

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W. A. Plunkett

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ABSTRACT

Procedure WPS-1009 is qualified under Section IX of the ASME Boiler and Pressure Vessel Code for manual gas tungsten arc (DC) and semiautomatic gas metal arc (DC) welding of aluminum alloys 6061 and 6063 (P-23), in thickness range 0.187 to 2 inch; filler metal is ER4043 (F-23); shielding gases are helium (GTAW) and argon (GMAW).

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
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MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-840R21400
## Manual Gas Tungsten Arc (DC) and Semi-automatic Gas Metal Arc Welding of 6XXX Aluminum

### Procedure Specification: WPS-1009

**Fabrication Department**  
**P & E Division**

### Procedure Qualification

**Specifications**: ASME Code Section IX.  
**Records**: PQR-1009-1 & -2.

### Base Metal-A
- **Grade or Alloy**: 6061 & 6063.  
- **Specifications**: ASME Code or Job Specs.  
- **P-Number-Group**: P-23.  
- **Ferm/Thickness**: Any. 0.187 – 2.0-in.

### Filler Metal-A
- **Classification**: ER4043.  
- **Specifications**: SFA-5.10 & ORNL Specs.  
- **F- & A-Numbers**: F-23.  
- **Form of Filler**: Straight/spooled solid weld-rod.

### Filler Metal-B
- **Specifications**: Same.  
- **F- & A-Numbers**: F-23.  
- **Form of Filler**: Same.  
- **Filling**: Same.

### Performance Qualification

Determine that the welder is qualified and has welded to this WPS within 90 days.

### Joint and Groove Preparation

**Joint Geometry**: JG-1009.  
**Joint Design**: Job Specs.

**Precautions**: Prevent contamination of joint and adjacent base metal from other metals (fixtures, tools, etc.).

**Cutting Defects**: File, grind or machine to produce smooth surfaces. Remove 0.06-in. metal from surfaces cut by PAC.

**Scale and Oxide**: Remove within 1-in. of joint.

**Foreign Material**: Remove within 6-in. of joint.

**Filing**: Immediately before welding, file groove face and base metal within 0.25-in. of joint to expose bright new metal.

### Weld Joint Assembly

**Fixtures**: Provide necessary clean fixtures to align and support parts during welding. Use temporary welds only where necessary.

**Backing**: Gas. (Optional).  
**Retainers**: None.

**Protection**: Provide necessary shelter or screen for weld area to exclude foreign material and drafts that contaminate arc shielding.

**Cleanliness Examination**: Immediately before welding examine groove face and adjacent base metal for foreign material.

**Tack Welds**: Deposit short thin beads equally spaced along root of joint. Clean tack welds, examine, taper ends as necessary and remove defects.

**Back Gouging**: File, grind or machine the root of joint to remove defects.

### Welding Position

Flat position (1G).

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**Welding Technologist**

**Approved By**: D. R. Frizzell  
**Welding Engineer**

**Approved By**: C. H. Woatke  
**Welding Metallurgist**

Date: Oct. '84  
Rev.: 0  
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## WELDING PROCESSES AND EQUIPMENT

### GTAW PROCESS & CONTROL
- **Gas tungsten arc welding**, manual.
- **Shield Gas**: 99.995 (min) helium. **Backing Gas**: Helium (Optional). **Trail Gas**: None.
- **Current**: Direct, electrode negative (straight polarity).
- **Current Source**: Rectifier or generator (drooping V-A curve) with foot slope-control.
- **Arc Starter**: High-frequency oscillator (touch start optional).
- **Electrode Spec**: AMS A5.12, Class EWTh-2, tungsten.

### GTAW PROCESS & CONTROL
- **Gas metal arc welding** (spray arc), semiautomatic.
- **Shield Gas**: 99.995 (min) argon. **Backing Gas**: None. **Trail Gas**: None.
- **Current**: Direct, electrode positive (reverse polarity).
- **Current Source**: Rectifier (constant potential V-A curve) listed on JWP.
- **Wire Feeder**: Suitable unit with electronic speed regulation and postflow timer listed on JWP.
- **Gun**: Listed on JWP.

### PREHEAT AND INTERPASS TEMPERATURE
- **GTAW Preheat Temp**: 60 — 200 F. **Equipment**: Oxyacetylene torch or resistance heater.
- **GMAW Preheat Temp**: 60 — 200 F. **Interpass Temp**: 300 F maximum.
- **Temp Check**: Contact pyrometer or thermocouple.

### WELDING OF JOINT
- **Welding Parameters**: Apply applicable Joint Welding Procedure.
- **Travel**: Upward if weld axis is not level.

#### GTAW PROCESS
- **Electrode**: Single. **Dimensions**: Sketch-1.
- **Weld Bead Type**: Stringer bead. **Travel Angle**: Sketch-2.
- **Technique**: Position torch. Start preflow; purge air from torch. Start arc at low current, when stable, upslope to welding current.
  - Feed welding rod at uniform rapid rate into leading edge of weld pool. Keep end of rod in shielding gas. Remove oxidized end of rod.
  - To stop a weld bead, fill weld pool, downslope current, when pool is at minimum size, break arc. Start postflow to minimize oxidation of electrode and weld bead.

#### GMAW PROCESS
- **Electrode**: Single. **Dimensions**: Sketch-3.
- **Weld Bead Type**: Stringer bead and weave bead. **Travel Angle**: Sketch-4.
- **Technique**: Remove oxidized end of electrode. Start preflow; purge air from gun. Position gun; start arc.
  - Weave gun at uniform rate with dwell at each side of weld bead.
  - To stop a weld bead, fill weld pool, increase travel speed, break arc. Maintain 10-sec (min) postflow.

### CLEANING OF WELD BEADS
- Brush, file or grind to remove oxide, spatter and other deposits from each weld bead and adjacent base metal.

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**WPS-1009**

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<table>
<thead>
<tr>
<th>PEERING</th>
</tr>
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<tbody>
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<td>None.</td>
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<table>
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<th>DEFECTS</th>
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<tr>
<td>Before depositing each weld bead, examine groove and adjacent base metal for cracks, laminations and other defects. Report such defects.</td>
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<tr>
<td>Examine each bead and layer for abnormal surface and contour, incorrect size or reinforcement, cracks, pits, incomplete fusion, inadequate joint penetration, overlap, undercut, underfill, inclusions, oxide, etc.</td>
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<td>Remove weld defects by filing, grinding or machining.</td>
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<th>POSTWELD HEAT TREATMENT</th>
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<th>EXAMINATION</th>
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<tr>
<td>Job Specs.</td>
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</table>
SKETCH-1  TUNGSTEN ELECTRODE DIMENSIONS

Ta = 0 - 15°
TORCH TRAVEL
(Forehand Welding)

SKETCH-2  TRAVEL ANGLE (TA)

±1/32"  
1/8"  
5/8"

SKETCH-3  GUN DIMENSIONS

GUN TRAVEL

±0
-15
90°

SKETCH-4  TRAVEL ANGLE (TA) - PLATE

TA = 12 - 15°
PIPE TRAVEL

SKETCH-5  TRAVEL ANGLE (TA) - CYL.
<table>
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<tr>
<th>GROOVE TYPE</th>
<th>DIMENSIONS</th>
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<tr>
<td>Thickness T (in.)</td>
<td>Bevel B (deg)</td>
</tr>
<tr>
<td>G-1 SINGLE-V</td>
<td>0.575 to 1.0</td>
</tr>
<tr>
<td>G-2 DOUBLE-V</td>
<td>1.0 to 2.0</td>
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M = Misalignment max: 0.1T for T to 0.2-in.
1/32-in. for T over 0.2-in.
### JOINT WELDING PROCEDURE

**Current source:**
- GTAW. Gen. or Rect. Linde SVI-300.
- GMAW. Airco AHF-E or Linde SEH-3.

**Wire feeder:**
- Airco AHF-E or Linde SEH-3.
- Airco AH-35B ST-9 or equal.

**WPS-1009**

<table>
<thead>
<tr>
<th>JOINT THICKNESS (T)</th>
<th>BEAD &amp; TYPE</th>
<th>PREHEAT INTERPASS TEMP (F) Min - Max</th>
<th>ROD, ELECTRODE DIAM (in.)</th>
<th>TRAVEL (ipm)</th>
<th>PROCESS, CURRENT, SETTINGS</th>
<th>CURRENT SOURCE SVI-300</th>
<th>TORCH (T)/GUN (G)</th>
<th>GAS (cfh)</th>
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<tr>
<td>0.375</td>
<td>1-S</td>
<td>60 - 200 1/8</td>
<td>0.035</td>
<td>180 28</td>
<td>GTAW dc(-) CURRENT A±10% V±10%</td>
<td>1/8 0.5 45</td>
<td>0.675 40</td>
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<tr>
<td></td>
<td>2-W</td>
<td>300 1/16 188</td>
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<td></td>
<td>GMAW dc(+), CURRENT A±10% V±10%</td>
<td>1/8 0.5 45</td>
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<td>0.375</td>
<td>3-W</td>
<td>300 1/16 188</td>
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<td>SLOPE STEEP FLAT VOLTAGE HIGH LOW</td>
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<tr>
<td>1.0</td>
<td>1-S</td>
<td>60 - 200 1/8</td>
<td>0.035</td>
<td>210 30</td>
<td>INDUCTANCE TUNG. DIAM HIGH LOW</td>
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<td>0.675 45</td>
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<tr>
<td></td>
<td>2-W</td>
<td>300 1/16 216</td>
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<td>NOZZLE DIAM Ar Ar</td>
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<td>300 1/16 216</td>
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<td>1/32&quot;Max 0.0&quot; 0.010&quot;</td>
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<td>1.0</td>
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<td>0.035</td>
<td>240 26</td>
<td>JOINT GEOMETRY (JG-1009) SINGLE-V</td>
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<td>2-W</td>
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<td>WELD BEAD SEQUENCE</td>
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<td>4-W</td>
<td>300 1/16 255</td>
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**Note:**
- S = Stringer bead.
- W = Weave bead.