Understanding “Position” in Welding

Walter J. Sperko, P. E.
Sperko Engineering Services, Inc.
4803 Archwood Dr.
Greensboro, NC 27406
www.sperkoengineering.com
sperko@asme.org
336-674-0600
FAX 336-674-0202

This presentation is copyrighted by Sperko Engineering

• General permission is granted for use of this presentation including printing thereof for educational purposes provided credit is given to Sperko Engineering.
• Use of the figures herein in any other publication without specific written permission is prohibited.
This presentation is copyrighted by Sperko Engineering

- The primary purpose of this presentation is twofold:
  - Make sure that code users understand the difference between testing positions and production welding positions
  - Help users understand how to read the figures that define production welding positions shown on the next page.

Production Welding Positions

Groove Welds

Fillet Welds
Standard **Test** Positions

Positions 1G, 3G, 6G, 2F, 5F, etc. are specially defined standard positions used for testing. They are properly referred to as Test Positions. Similar positions are found in ISO 6947 identified as PA, PC, PG, etc.

---

Standard **Testing** Positions

Test positions are discreetly defined positions of test coupons that are used when mostly when testing welders. These positions have tolerance of $\pm 15^\circ$ from the defined horizontal planes and $\pm 5^\circ$ from a defined vertical or inclined plane. See QW-120
Testing Position 1G/PA

Weld Axis Horizontal

±15°

Plate Horizontal

±5°

Test Position 2G/PC

Weld Axis Horizontal

±5°

Plates Vertical

±15°
Test Position 3F/PF or PG

Test Position 6G/HL045 or JL045
Test Positions are **Discreetly Defined**

- Because of tolerance limits on test positions, positions in between test positions are undefined!
- That is, a weld that is inclined $22^\circ$ uphill and rotated $36^\circ$ about its axis has no “G” or “F” position. Such a position, however, may be encountered during production welding.
- Production welding positions, therefore, need to be defined contiguously.

---

Test Positions **Qualify Welders for Specific Welding Positions**

**Test Positions ➔ Welding Positions**

Translations from test positions to welding positions are made in the construction codes. QW-461.9 is typical.
### Test Positions ➤ Welding Positions

<table>
<thead>
<tr>
<th>Welding Positions</th>
<th>Position and Type Weld Qualified (Note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plate and Pipe (Note 1)</td>
</tr>
<tr>
<td></td>
<td>Groove</td>
</tr>
<tr>
<td>Plate - Groove</td>
<td>1G</td>
</tr>
<tr>
<td></td>
<td>2G</td>
</tr>
<tr>
<td></td>
<td>3G</td>
</tr>
<tr>
<td></td>
<td>4G</td>
</tr>
<tr>
<td></td>
<td>3G and 4G</td>
</tr>
<tr>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Special Positions</td>
<td>SP, F</td>
</tr>
<tr>
<td>Plate - Fillet</td>
<td>1F</td>
</tr>
<tr>
<td></td>
<td>2F</td>
</tr>
<tr>
<td></td>
<td>3F</td>
</tr>
<tr>
<td></td>
<td>4F</td>
</tr>
<tr>
<td>Special Positions</td>
<td>3F and 4F</td>
</tr>
<tr>
<td></td>
<td>All</td>
</tr>
</tbody>
</table>

| Pipe - Groove (Note 3) | | |
|------------------------|------------------|
| Plate and Pipe         | Plate and Pipe |
| Groove                 | Groove |
| 1G                     | F            |
| 2G                     | F, H         |
| 3G                     | F, V         |
| 4G                     | F, O         |
| 3G and 4G              | All          |
| Special Positions (SP) | F, H, O      |

| Pipe - Fillet (Note 3) | | |
|------------------------|------------------|
| Plate and Pipe         | Plate and Pipe |
| Groove                 | Groove |
| 1F                     | F            |
| 2F                     | ...          |
| 3F                     | ...          |
| 4F                     | ...          |
| Special Positions (SP) | F, H, O      |

Note to table:

1. Positions of welding as shown in QW-461.1 and QW-461.2

   - **F** = Flat
   - **H** = Horizontal
   - **V** = Vertical
   - **O** = Overhead

2. Pipe 2-7/8 in outside diameter and over.

© Sperko Engineering 2005
WWW.SPERKOENGINEERING.COM
OM
Welding positions for groove welds are defined by the following diagram.

NOTE
Welding Position Diagrams are contiguous.
Tabulation showing transition points between welding positions

Tabulation of Positions of Groove Welds

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>A</td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td>HorizontalB</td>
<td>0 to 15°</td>
<td>80 to 150°</td>
<td>210 to 280°</td>
</tr>
<tr>
<td>Overhead</td>
<td>C</td>
<td>0 to 80°</td>
<td>0 to 80°</td>
</tr>
<tr>
<td>Vertical</td>
<td>D</td>
<td>15 to 80°</td>
<td>80 to 280°</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

How this table and the diagram on the previous page work are shown in the following diagrams.

Let’s start with the Flat Position
## Welding Positions

Tabulation of Positions of Groove Welds

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>A</td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td>Horizontal</td>
<td>B</td>
<td>0 to 15°</td>
<td>80 to 150°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 280°</td>
</tr>
<tr>
<td>Overhead</td>
<td>C</td>
<td>0 to 80°</td>
<td>0 to 80°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 360°</td>
</tr>
<tr>
<td>Vertical</td>
<td>D</td>
<td>15 to 80°</td>
<td>80 to 280°</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

How this table and the diagram on the previous page work are shown in the following diagrams.
Start at Nominal Flat Position

Face of weld is up

Flat Upward Inclined Limit

Weld may *incline upward* to a limit of 15°
Flat Upward Inclined Limit

But the welder could be traveling *down the incline*...
# Welding Positions

Tabulation of Positions of Groove Welds

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat A</td>
<td></td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td>Horizontal B</td>
<td></td>
<td>0 to 15°</td>
<td>80 to 150°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 280°</td>
</tr>
<tr>
<td>Overhead C</td>
<td></td>
<td>0 to 80°</td>
<td>0 to 80°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 360°</td>
</tr>
<tr>
<td>Vertical D</td>
<td></td>
<td>15 to 80°</td>
<td>80 to 280°</td>
</tr>
<tr>
<td>Vertical E</td>
<td></td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

How this table and the diagram on the previous page work are shown in the following diagrams.

---

## Flat Position --Rotation About Axis

![Diagram of Flat Position Rotation](image)

© Sperko Engineering 2005

WWW.SPERKOENGINEERING.COM

© Sperko Engineering 2005
Flat Rolled Limit Clockwise

Equivalent to rotating the plate 30°
Flat Rolled Limit Counterclockwise

150°  180°  30°

Flat Rotated Limits Not Considering Inclination

60°
Welding Positions

Tabulation of Positions of Groove Welds

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>A</td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td>Horizontal</td>
<td>B</td>
<td>0 to 15°</td>
<td>80 to 150°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 280°</td>
</tr>
<tr>
<td>Overhead</td>
<td>C</td>
<td>0 to 80°</td>
<td>0 to 80°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 360°</td>
</tr>
<tr>
<td>Vertical</td>
<td>D</td>
<td>15 to 80°</td>
<td>80 to 280°</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

How this table and the diagram on the previous page work are shown in the following diagrams
Flat Downhill Limit Rotated

Composite Flat Position Ranges
Compare this range to 1G/PA. . .

Testing Position 1G/PA

Weld Axis Horizontal

Plate Horizontal

±5° ±15°
Flat ≠ 1G!!!!

Welding Positions

Tabulation of Positions of Groove Welds

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>A</td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td><strong>Horizontal</strong></td>
<td><strong>B</strong></td>
<td><strong>0 to 15°</strong></td>
<td>80 to 150°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 280°</td>
</tr>
<tr>
<td>Overhead</td>
<td>C</td>
<td>0 to 80°</td>
<td>0 to 80°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 360°</td>
</tr>
<tr>
<td>Vertical</td>
<td>D</td>
<td>15 to 80°</td>
<td>80 to 280°</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

How this table and the diagram on the previous page work are shown in the following diagrams.
Horizontal Position Axis Inclined

Basic Horizontal Position
Horizontal Position Uphill
Inclined Limit

Horizontal Position Downhill
Inclined Limit
Welding Positions

Tabulation of Positions of Groove Welds

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>A</td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td>Horizontal</td>
<td>B</td>
<td>0 to 15°</td>
<td>80 to 150°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 280°</td>
</tr>
<tr>
<td>Overhead</td>
<td>C</td>
<td>0 to 80°</td>
<td>0 to 80°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>210 to 360°</td>
</tr>
<tr>
<td>Vertical</td>
<td>D</td>
<td>15 to 80°</td>
<td>80 to 280°</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

How this table and the diagram on the previous page work are shown in the following diagrams.
Start at the Flat Rolled Limits

Let’s go to an end view . . .

Horizontal End View

Horizontal starts where Flat ends . . .
Horizontal Rotates to where the plate is perpendicular to the ground

Horizontal rotates clockwise . . .

Horizontal Position Rotated Limit

Horizontal ends here . . .
Non-inclined Horizontal Position Limits

Starts with plate rotated 30°

Non-inclined Horizontal Position Limits

Finishes with plate rotated 10° beyond perpendicular
Composite Horizontal Position Limits

Compare Horizontal to 2G/PC
Test Position 2G/PC

Weld Axis
Horizontal

±15°

±5°

Plates Vertical

Horizontal ≠ 2G/PC !!!!
Overhead Position

80°

280°

160° range

Basic Overhead

Face of weld is overhead!!!
Same Rotation in Isometric View

Basic Overhead

Face of weld is overhead

0°
Overhead Partial Rotation
Isometric View

Face of weld is overhead

Overhead Maximum Rotation
Isometric View

Face of weld On this side

280°
Overhead Maximum Opposite Rotation Isometric View

Face of weld is on this side

Overhead Position
Axis Inclination

80° range

160° range

280°
Overhead Inclined Axis Limit

Weld can rotate 360° about vertical axis while inclined 10° forward tilt.
Overhead Inclined Axis Limit

Weld can rotate about the vertical axis.
Overhead Inclined Axis Limit

0°

Weld can rotate about
The vertical axis

10°
Overhead Inclined Axis Limit

Weld can rotate about
The vertical axis

© Sperko Engineering
2005
Overhead Inclined Axis Limit

Weld ends up back Where it started!

Composite Overhead Position Limits
Overhead ≠ 4G/PE !!!!

Vertical Position Part 1

65° Range of Inclination
From 15 to 80°.
Face of weld is up

15°
Vertical Position Part 1

Range of inclination
Starts at 15°
Face of weld is up

Greater than 15°
Vertical Position Part 1

Until reaching 80°

Vertical Position Part 2

When the “E” portion of the diagram is reached
Vertical Position Part 2

The “E” portion of the diagram -- 360° Rotation About vertical axis
Vertical Position Part 2

Partial rotation about Vertical axis

Vertical Position Part 2

More rotation about Vertical axis
Vertical Position Part 2

Even more rotation about Vertical axis

Vertical Position Part 2

Rotated 180° about Vertical axis
Vertical Position Part 2

Continuing Rotation about Vertical axis
Vertical Position Part 2

Continuing Rotation about Vertical axis

Vertical Position Part 2

360° of Rotation about Vertical axis completed
Vertical Position Part 3

200° Range of Rotation

80°

Vertical Position Part 3

Start here with inclination Uphill or Downhill 15° Face of weld upward

15°
Vertical Position Part 3

Rotate face while holding Inclination constant

Vertical Position Part 3

Continue rotating with Inclination constant
Vertical Position Part 3

Rotated to vertical limit
Inclination constant

Return to starting position
Uphill or Downhill 15°
Face of weld upward
Vertical Position Part 3

 Rotate face of weld
Opposite direction
Inclination Constant 15°

15°

Vertical Position Part 3

Continue rotating
Opposite direction
Inclination Constant 15°

15°
Vertical Position Part 3

Plate near vertical
Inclination Constant 15°

Plate at vertical limit of rotation.
Inclination Constant 15°
Vertical Position Part 3

200° Range of Rotation inclined Uphill or Downhill 15°

80°

15°

280°

80°

200° Range of Rotation Inclination angle Increases

280°
Vertical Position Part 3

200° Range of Rotation
Inclination angle
Increases more...
Welding Positions for **Fillet** Welds

Flat Fillet Weld
Horizontal Fillet Weld

Welding Positions for Fillet Welds
## Welding Positions for Fillet Welds

**Tabulation of Positions of Fillet Welds**

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis</th>
<th>Rotation of Face</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>A</td>
<td>0 to 15°</td>
<td>150 to 210°</td>
</tr>
<tr>
<td>Horizontal</td>
<td>B</td>
<td>0 to 15°</td>
<td>125 to 150°</td>
</tr>
<tr>
<td>Overhead</td>
<td>C</td>
<td>0 to 80°</td>
<td>0 to 125°</td>
</tr>
<tr>
<td>Vertical</td>
<td>D</td>
<td>15 to 80°</td>
<td>125 to 235°</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>80 to 90°</td>
<td>0 to 360°</td>
</tr>
</tbody>
</table>

The Horizontal Range Is smaller for fillet welds Than it is for groove welds
Welding Positions for Groove Welds

Questions?
Feedback?
Can you explain the diagrams to your friends?

Send e-mail to:
Sperko@asme.org

© Sperko Engineering 2005
WWW.SPERKOEENGINEERING.COM