SMAW
“Stick” Welding

Disadvantages of SMAW
- Not suitable for sheet metal under 1/16-inch thickness.
- Lower operator duty cycle and deposition rate than wire-fed processes.
- Not all of the electrode is consumable.
- Frequent stops and starts during electrode change increases the chances of weld defects.

AWS Definition
An arc welding process with an arc between a covered electrode and the weld pool. The process is used with shielding from the decomposition of the electrode covering, without the application of pressure, and with filler metal from the electrode.

SMAW Current
- AC – Alternating Current
- DCEN (DCSP) – Direct Current, Electrode Negative (Straight Polarity)
- DCEP (DCRP) – Direct Current, Electrode Positive (Reverse Polarity)

Shielded Metal Arc Welding
- Least expensive equipment
- Most portable
- 1/8" thick plate or greater
- Almost any type of metal
- Weld quality highly dependent on welder skill
- Used in any position

SMAW Current
- DC Provides a more stable arc than AC.
- AC arc extinguishes and re-ignites 120 times a second.
- DC has shorter arc length – preferred on overhead and vertical welds.
- Arc blow (deflection of arc due to magnetic field) can be a serious problem with DC.
**SMAW Current**

There is no particular advantage of using AC over DC current with SMAW other than lower power equipment costs and limitations of possible arc blow problems.

Most combination electrodes for use with both AC and DC current work better on DC.

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**AC – Alternating Current**

Heat evenly balanced between electrode and base plate

Electrode

1/2 Heat

Electron flow reverses 120 times a second

Base Plate 1/2 Heat

**Weld Penetration**

DCEN AC DCEP

**Reverse Polarity – DCRP**

(Electrode Positive (DCEP))

More heat at electrode (greater deposition)

Electrode (Positive, anode)

2/3 Heat

1/3 Heat

Base Plate (Negative, cathode)

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**Straight Polarity – DCSP**

(Electrode Negative (DCEN))

More heat at base plate (greater penetration)

Electrode (negative, cathode)

1/3 Heat

Base Plate (Positive, anode) 2/3 Heat

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**Electrode Designation (ASTM)**

E 6 0 1 3

Current Position Tensile Strength ($F_u$) in ksi Arc Welding Electrode
Match Weld Metal to Base Plate

Matching Weld Metal

E60XX - A36 Steel ($F_u = 58$ ksi)
E70XX - A992 and other Gr. 50 Steels ($F_u = 65 - 70$ ksi)

(OK to mismatch electrode strength one level above base plate strength: E70XX for A36)

Welding Positions

- F = Flat
- H = Horizontal
- V = Vertical
- OH = Overhead
Welding Positions
Pipe Horizontal - 5

Electrode Coating
✓ Provides a gas stream to shield the molten weld pool from the atmosphere.
✓ Supplies scavengers, deoxidizers, and fluxing agents to clean the weld.
✓ Provides chemicals to the arc that control the electrical characteristics of the electrode.
✓ Covers the finished weld with slag.
✓ Adds alloying elements to the weld pool.

Electrode Coating
The burning and vaporizing of the flux covering produces the shielding gas.
3 types of flux are used:
1. Cellulose-based
2. Rutile-based (ore of titanium)
3. Mineral-based

Electrode Coating
Iron powder is added to the coating to increase the weld temperature and deposition rate.
Potassium in the coating makes the gases of the plasma readily ionize which improves AC operation since arc extinguishes and re-ignites 120 times a second.
The shielding gas and deoxidizers prevent the pickup of oxygen and nitrogen.

Electrode Current and Coating

<table>
<thead>
<tr>
<th>Designation</th>
<th>Current</th>
<th>Type of Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXXX0</td>
<td>DCEP only</td>
<td>Cellulose sodium</td>
</tr>
<tr>
<td>EXXX1</td>
<td>AC and DCEP</td>
<td>Cellulose potassium</td>
</tr>
<tr>
<td>EXXX2</td>
<td>AC and DCEN</td>
<td>Titania sodium</td>
</tr>
<tr>
<td>EXXX3</td>
<td>AC and DC</td>
<td>Titania postassium</td>
</tr>
<tr>
<td>EXXX4</td>
<td>AC and DC</td>
<td>Iron powder titania</td>
</tr>
<tr>
<td>EXXX5</td>
<td>DCEP only</td>
<td>Low hydrogen sodium</td>
</tr>
<tr>
<td>EXXX6</td>
<td>AC and DCEP</td>
<td>Low hydrogen potassium</td>
</tr>
<tr>
<td>EXXX7</td>
<td>AC and DC</td>
<td>Iron powder iron oxide</td>
</tr>
<tr>
<td>EXXX8</td>
<td>AC and DCEP</td>
<td>Iron powder low hydrogen</td>
</tr>
</tbody>
</table>

Common Electrode Types
H8 = Low Hydrogen Electrode
E6011 Electrode
✓ Used with AC or DCEN.
✓ Organic-based flux with added arc stabilizers so that it can be used with AC.
✓ High forceful action of the rapidly expanding shielding gas. Can cause concave weld pool. Results in more spatter and sparks during welding.
✓ Good penetration due to forceful arc.
✓ Small amount of slag remains on the finished weld but is difficult to remove.

SMAW Current
The SMAW process uses a power supply that provides Constant Current (CC) of a certain operating range.

ΔV
Small ΔA
Current - Amperes

E6013 Electrode
✓ Used with AC or DC (either polarity).
✓ Rutile-based flux.
✓ Very stable arc.
✓ Shallow penetration since the arc is not very forceful.

SMAW Arc Length
As the arc length or gap increases, the current remains approximately constant. This provides a stable arc.

The arc spreads out over a greater area and creates a larger but shallower weld pool which freezes more quickly (more splatter also).

The arc length should be between 1/8 and 3/16 inches.

E7018 Electrode
✓ Used with AC or DCEP.
✓ Low hydrogen based flux with added iron powder.
✓ Moderate penetration and buildup.
✓ The weld metal is projected from the atmosphere by the molten slag layer and not by the expanding gases.
✓ The slag is heavy but is easily removed by chipping.

SMAW Amperage Range

<table>
<thead>
<tr>
<th>Electrode Diameter</th>
<th>E6011</th>
<th>E6013</th>
<th>E7018</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/32 in.</td>
<td>50 - 70</td>
<td>40 – 85</td>
<td>70 - 110</td>
</tr>
<tr>
<td>1/8 in.</td>
<td>85 - 125</td>
<td>75 – 120</td>
<td>90 - 165</td>
</tr>
<tr>
<td>5/32 in.</td>
<td>130 -160</td>
<td>130 - 160</td>
<td>125 - 220</td>
</tr>
</tbody>
</table>
**Striking the Arc**

To start the arc, scratch the electrode across the plate (like striking a match).

Once the arc is established raise the electrode slightly and allow the weld pool to form.

**Leading Electrode Angle**

The arc force pushes molten weld metal out and ahead of the weld pool, onto the cooler base plate. This causes the molten metal to spread out. The heat is spread over a wider area. Can trap inclusions and other defects.

**Striking the Arc Accurately**

Hold the electrode by resting it in your free hand, much like a pool cue.

Rapidly push the electrode forward so it strikes the plate at desired location.

**Trailing Electrode Angle**

Directs the arc force back into the molten weld pool. This force the molten metal back onto the trailing edge of the pool, exposing more of the unmelted base metal.

**Ending the Weld**

Normal welding prior to ending.

Pause briefly to let the weld pool build up.

Backtrack before breaking the arc.