Stick Electrodes

Weld Tech News

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WELD TECH NEWS is a newsletter for welders working primarily in maintenance and repair. Each issue contains useful information on materials (cast irons, steels, aluminum, copper alloys, etc.), welding products and welding techniques. By collecting each issue, the reader will soon have a handy reference manual covering all aspects of welding, brazing and soldering for maintenance and repair.

STICK ELECTRODES

Shielded Metal Arc Welding (SMAW)

The gas shielded welding processes, especially wire feed welding, have undergone great growth in the welding industry. Machines for gas tungsten arc welding (GTAW) have become more sophisticated and machines for gas metal arc welding (GMAW) and flux core arc welding (FCAW) have spread from large scale metal fabricators to home hobbyists. Despite the growth of these other weld processes stick electrode welding is still a very popular and highly used method.

Stick welding requires inexpensive equipment that is highly portable and can be accomplished far from the power source. It can be done outdoors. Many stick electrodes can be run in all positions. Ferrous and non-ferrous metals can be welded and in thicknesses from 18 gauge on up. Weld quality can be consistently high. A welder can easily switch from welding one type of metal to another by simply switching electrodes. Stick welding is very popular for repair and maintenance applications due to such versatility.

The main drawback of the process is its relatively low deposition efficiency which makes it less suitable than the wire feed processes for fabrication applications. Also it cannot be used to weld some non-ferrous metals, such as titanium, which require the gas tungsten arc process (GTAW).

Stick electrodes evolved from the use of carbon electrodes as a means to create an electric arc and therefore a high heat. Around 1889, metal rods were used instead of carbon as electrodes. The first metal electrodes were bare, no flux coating. These electrodes produced an unstable arc and welds with porosity and impurities. In the early 1900's coatings on the bare wires evolved. Paper and fabric coatings such as asbestos led the way to the flux coatings we now use. Stick electrodes were first used in ship building during World War One and became a major metal fabrication method in the early 1930's.

Shielded Metal Arc Welding (SMAW) – 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. (ANSI/AWS A3.0:2001)
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Two key points must be remembered with regards to welding. First, whenever we heat metal up we must protect it from the atmosphere. Secondly, a weld is a combination of molten base metal combined with the molten metal coming off of the electrode so the weld is actually a third metal of combined molten base metal and electrode.

**Covered electrode** – a composite filler metal electrode consisting of a core of a bare electrode or metal cored electrode, to which a covering sufficient to provide a slag layer on the weld metal has been applied. The covering may contain materials providing such functions as shielding from the atmosphere, deoxidation, and arc stabilization, and can serve as a source of metallic additions to the weld. (ANSI/AWS A3.0:2001)

Fluxes serve to protect the molten metal of the arc and to stabilize the arc. The heat of the arc melts the flux, forming a gas shield to protect the arc and ionizes the arc to stabilize it. We do not want molten metal to react with oxygen, so fluxes act as deoxidizers. Alloying elements can also be added to fluxes to combine with the metal from the core wire in the heat of the arc to add to the weld metal. Fluxes form a slag over the weld puddle which can help shape the deposit and protect the hot weldment while it cools.

Flux coatings can be made up of many ingredients including cellulose, feldspar, metal carbonates, metal silicates, iron powder, clays and binders. There can be great differences among flux coated electrodes.

**LOW HYDROGEN**

Many types of electrodes have a cellulosic flux coating and this was the earliest type of coating developed. These types of flux coatings need moisture levels of 3-7% to work properly. In fact if they are dried too much from improper storage they will produce welds that will not pass inspection. In the 1930's metal fabricators began to work with stainless steels. The electrodes of the time did not make good welds on stainless due to porosity in the welds. It was found that this was due to hydrogen. As we all know, water is hydrogen and oxygen. The moisture in the flux coating broke down in the heat of the arc causing porosity in the stainless welds. This initiated the development of the low hydrogen (low-hy) electrodes.

The steel industries developed methods to effectively produce high carbon, high strength steels in the 1940's. When these newer types of steels were welded with the cellulosic coated electrodes, problems with weld cracking became apparent. Known as hydrogen induced or underbead cracking, investigation revealed that these steels were susceptible to cracking from hydrogen introduced into the welds from the electrodes. The moisture in the electrodes being the source.

**Hydrogen embrittlement** - a condition that causes a loss of ductility and which exists in weld metal due to hydrogen absorption. In some metals the loss of ductility induces cracking. Underbead cracking may also be caused by hydrogen embrittlement of the weld. (Welding Encyclopedia, 18th Edition)

Hydrogen induced cracking usually occurs below 200°F (93°C) immediately upon cooling or after a few hours. That would be for most low-alloy steels. For chromium-molybdenum steels, cracking would occur below 300°F (149°C). For low-alloy, high strength and alloy steels the likelihood of hydrogen induced
cracking increases with the degree of available hydrogen, tensile strength and stresses. Low carbon steels are relatively free from hydrogen induced cracking. This cracking may appear as toe cracks in the heat affected zone, centerline root cracks, transverse weld cracks or underbead cracks. Hydrogen embrittlement can also lower the mechanical properties and impact resistance of metals affected by it.

**Underbead crack** - a heat-affected zone crack in steel weldments arising from the occurrence of a crack-susceptible microstructure, residual or applied stress, and the presence of hydrogen. (ANSI/AWS A3.0:2001)

Another source of hydrogen induced cracking can be moisture from the base metal or from other contaminants. Obviously, cleaning the weld area may be necessary and preheating to remove surface moisture or condensation may be required. Failure to pre or post heat can actually be another reason for cracking separate from any hydrogen induced cracking. Depending on the type of steel, thickness and alloy content, preheat may be required regardless of any hydrogen contamination problems.

All mild steel electrodes have a core wire of rimmed steel with very controlled carbon contents. Low-hydrogen electrodes use the same core wire but have a very different flux coating with a moisture content of the flux being less than 0.15%. These types of electrodes may be hygroscopic and may require special care to operate properly and provide welds that pass inspection. Hygroscopic means the flux can absorb moisture from the atmosphere when exposed to air; this in turn can introduce hydrogen to the weldment.

Great advances have been made in the development of flux coatings. Some low-hydrogen electrodes may be more susceptible to moisture absorption than others. The effect of moisture on the flux coatings of low-hydrogen electrodes can vary depending on exposure time, humidity levels and temperature. Welders should follow recommendations of the manufacturer for electrode storage and conditioning but the basic rule for storage of opened containers of low-hydrogen electrodes would be about 200°F (149°C).

Remember electrodes with a cellulosic flux coating, such as mild steel electrodes, need a moisture content of 3-7%. They can become too dry at temperatures above 125°F (52°C). This can be detrimental to their running characteristics so these types of electrodes should not be stored in rod ovens at the same temperatures as low-hydrogen electrodes.

Welding with low-hydrogen electrodes is different that running conventional electrodes. Stringer beads are more common. Some iron powder type low-hydrogen electrodes will have an iron powder content of 40% in the flux coating giving them good deposition rates. The molten flux serves to help shield and shape the puddle more than other electrode types. Doing proper vertical welds requires more skill. Re-striking a low-hydrogen electrode is more difficult due to the flux coating wanting to cover over the tip of the core wire when the arc is broken. The first consideration as to the use of a low-hydrogen electrode should be the type of steel to be welded.

The following principles directly relate to shielded metal arc welding (SMAW). They are also relevant to the other arc welding processes, so an understanding of these principles will help with the understanding of the wire feed and tungsten arc processes.
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**TRANSFERS**

The electric arc established between the electrode and the base metal creates intense heat. Up to 9000°F (5000°C) in the center of the arc. The heat of the arc melts the base metal and the end of the electrode. The molten metal at the end of the electrode transfers across the arc and combines with the molten base metal to give us a weld. There are two ways the molten metal can come off the electrode and transfer across the arc, depending on the type of electrode and proper amperage settings. A globular transfer is when large drops, one at a time, melt off the end of the rod and flow into the weld puddle. A spray transfer is when many small drops, at the same time, melt off the end of the rod and flow into the weld puddle. This would be similar to paint coming out of a spray can. These different transfers are why some rods seem to "run" differently than others.

**AC/DC**

We all probably know that there are two types of electrical currents. Alternating current (AC) is the type of current that comes out of a wall outlet. This current reverses the direction of its flow at regular intervals. In the case of a wall outlet, that current changes direction 60 cycles each second. For our purposes in regards to welding, with AC we have electricity, but no directional flow to that electricity since it keeps changing direction back and forth. If you run a stick rod on AC you will probably notice a fair amount of spatter and noise. If you run the same rod on DC it will run quieter with less spatter. On AC we are in effect striking and re-striking the arc every time the current changes direction. Some rods such as those for aluminum and some low-hy rods won't even run on AC.

There are many advantages of using direct current (DC) instead of alternating current. With smaller diameter electrodes and their lower currents it is better and all types of electrodes will work on DC. Starting an arc and maintaining a short arc is easier. Lower currents can be used with DC which makes out-of-position welding easier. DC is easier to use on sheet metal. Alternating current is better where magnetic arc blow is a problem and it is also efficient for running large diameter electrodes on thick base metal sections.

Direct current or DC means that the electrical current has directional flow. It flows one way or it flows the other way. That is two ways it can flow and with DC we have two polarities, straight and reverse.

**POLARITY**

Electricity flows from negative to positive. There is no real polarity with AC because the negative and positive keep changing but with DC, once you establish that current it is always flowing that direction. Straight polarity and reverse polarity are the "non-standard" terms for which direction the electrical current is flowing in a welding arc.

**Direct current electrode negative (DCEN)** – the arrangement of direct current arc welding leads in which the electrode is the negative pole and workpiece is the positive pole of the welding arc. (ANSI/AWS A3.0:2001)
Direct current electrode positive (DCEP) – the arrangement of direct current arc welding leads in which the electrode is the positive pole and the workpiece is the negative pole of the welding arc. (ANSI/AWS A3.0:2001)

So with DCEN (straight polarity) we have the current flowing out of the negative electrode (the weld rod) into the positive base metal because current flows negative to positive. With DCEP (reverse polarity) the current is flowing from the negative base metal, across the arc, into the end of the positive weld rod. This is important to understand because up to 70% of the heat of the arc is released at the positive side of the arc. One end of the arc on DC is hotter than the other. On DCEP it is end of the welding rod that is the hottest. The type of electrode determines the polarity but most stick electrodes run best on DCEP (see diagram below).

Constant current (CC) type power sources are preferred for SMAW because they provide a nearly constant current for the arc despite changes in the voltage. These types of power sources are also used for gas tungsten arc welding (GTAW) and submerged arc welding (SAW).

Constant current power source - an arc welding power source with a volt-ampere relationship yielding a small welding current change from a large arc voltage change. (ANSI/AWS A3.0:2001)

Constant current power sources, or "stick machines", are not commonly used for wire feed welding. If they are used for wire feed welding, it is in conjunction with a "voltage sensing feeder". These are sometimes called a "suitcase welder" and provide for constant voltage to run the wire. Wire feed welding is best done with constant voltage, which while maintaining nearly constant voltage, can provide a wide range of welding current.

Constant voltage power source - an arc welding power source with a volt-ampere relationship yielding a large welding current change from a small arc voltage change. (ANSI/AWS A3.0:2001)

When the voltage output decreases as the welding current increases this is called a "drooping" volt ampere characteristic. The constant current welding machine is providing for a nearly constant current for the welding arc while the welder running the rod holds a constant arc length off the end of the electrode. Only slight changes in the arc length causes small changes in the voltage, this in turn changes the welding current. Multi-process, multifunction welding machines are becoming more and more prevalent. They typically have a switch to go from one process to another, from stick welding to wire feed for example. This switch actually changes the power source between constant current and constant voltage.

SMAW ELECTRODES FOR JOINING

The following is a partial list and brief description of SMAW electrodes for joining applications. For a complete description and full list of SMAW electrodes for joining and hardfacing, as well as other welding products, please consult the ROCKMOUNT welding manual.
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**Brutus-AAA** (127,000 p.s.i.) and **Brutus-A** (125,000 p.s.i.) electrodes are chrome-nickel alloys suitable for a variety of steel applications including alloy steels and dissimilar steel joining.

**Apollo-B** (105,000 p.s.i.) is for joining and build-up on manganese and other steels including dissimilar steels. Deposits are tough and shock resistant and will work harden under impact. Suitable for joining applications, deposits can also be built to any thickness and can be overlaid with hardfacing deposits.

**Polaris-AAA** (98,000 p.s.i.) and **Polaris-A** (95,000 p.s.i.) are the low hydrogen choice for a wide variety of carbon and alloy steel applications. High elongation make them ideal for impact, vibration or thermal stress.

**Tartan-AAA** (86,000 p.s.i.) is the premier maintenance electrode suitable for low carbon, mild and medium carbon steels in less than ideal circumstances such as rusty, oily or wet. Can be run vertical down and over its own slag.

**Tartan-A** (80,000 p.s.i.) is a fast deposition, contact electrode that is easy to use on low carbon, mild and medium carbon steels. Low spatter.

**Tartan-B** (80,000 p.s.i.) is an aggressive deep penetration mild steel electrode. Exceptionally easy to use in all positions due to its fast freeze deposit. Excellent for welding pipe, dirty steel.

**Gemini-A** (85,000 p.s.i.) and **Gemini-B** (80,000 p.s.i.) stainless electrodes feature low carbon contents and superior corrosion resistance. Excellent out of position and with ultra-low spatter.

**Jupiter-AAA** (70,000 p.s.i.) and **Jupiter-A** (79,000 p.s.i.) are nickel electrodes especially suited for large, contaminated cast iron repairs as well as for joining steel to cast iron. Excellent for build-up, can do pass on pass over slag.

**Jupiter-BBB** (65,000 p.s.i.) and **Jupiter-B** (64,000 p.s.i.) are high nickel alloys that run excellent out of position and provide the most machinable deposits. Very ductile deposits minimize cracking. Weld over slag and can be run vertical down and on contaminated castings.

**Neptune-AAA** (35,000 p.s.i.) and **Neptune-A** (35,000 p.s.i.) are aluminum arc rods that can also be used with oxy-acetylene to braze. Can be used on most weldable aluminum cast, sheet and tubing. Requires DC welder. Low spatter.

**Venus-A** (50,000 p.s.i.), **Venus-B** (63,000 p.s.i.) and **Venus-C** (106,000 p.s.i.) are bronze alloy electrodes for joining and overlays on bronze, brass and steel. Also suitable for joining dissimilar metals such as steel to bronze. Deposits are machinable, ductile and corrosion resistant.
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![Diagram of welding connections for different polarities]

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