Introduction to E6010 Electrodes and Recommended Welding Techniques

By Kenneth Alrick, Senior Welding Business Manager, SanRex

Welding success depends on having the right tools and knowing how to use them. For welding pipe, welding out-of-position and field applications involving dirty or rusty metal, that means using E6010 SMAW (Stick) electrodes and welding power sources specifically designed to run this electrode.

Stick electrodes gain different characteristics because the coating composition varies by electrode type. Per ASME Section II part D (par. A7.1), "The coverings [on an E6010 electrode] are high in cellulose, usually exceeding 30% by weight. The other materials generally used in the covering include titanium dioxide, metallic deoxidizers such as ferromanganese, various types of magnesium or aluminum silicates, and liquid sodium silicate as a binder."

Because of the covering composition, E6010 electrodes are generally described as "cellulosic" or "high cellulose sodium" electrodes. These electrodes share the following characteristics:

- A deeply penetrating, forceful, spray type arc, which helps the operator achieve good tie-in on both sides of the joint when making a root pass.
- These "digging" characteristics also make E6010 electrodes a good choice for field repair work, as the digging arc can burn through rust, dirt and paint (still, there's no substitute for good weld preparation).
- A weld puddle that wets out well, yet cools quickly. This "fast freezing" attribute makes E6010 electrodes especially suitable for welding overhead. Operators like E6010 electrodes because the molten metal stays in the joint and doesn't fall down on them as much compared to other all-position electrodes.
- A thin layer of slag that removes easily, simplifying cleanup and preparation for the next welding pass.
- A weld face that is flat with coarse, unevenly spaced ripples.

Combined, these attributes are why E6010 electrodes are specified for pipe welding, as well as for applications such as field construction, ship yards, water towers, pressure vessels, pressure pipes, steel castings and steel storage tanks.

Joint Preparation

Many of the applications for E6010 electrodes require 100 percent penetration. In the case of critical welds, 100 percent of the joints will undergo ultrasonic testing and other inspections. Ensuring complete fusion starts with good weld preparation, and for a typical E6010 open root butt weld, that means:

- Beveling the edges of the pipe or plate; a typical bevel is 37.5 degrees for pipe and 22.5 degrees for plate.

- Leaving a small “nickel width” land (about 3/32 to 1/8 inch). A land is the unbeveled portion of the metal at the edge of the joint. The metal needs to be thicker here to support the heat of the weld; otherwise, the force of the arc will “blow through” the joint.
- Creating a gap of about 3/32 to 1/8 inch (or according to specification). To ensure an even gap, an old pipe welder’s trick is to bend a length of 3/32- or 1/8-inch TIG filler into a U shape and insert it between the sections when tacking.

And speaking of tacking, make tack welds about 1-inch long, then use a grinder to taper or “feather” each end of the tack. The object is to have a tack thick enough to establish the arc without burn through, yet thin enough so that the heat of the arc consumes the tack. After establishing the arc, many operators briefly “long arc” the electrode to heat up the middle of the tack, then reduce arc length (“tighten the arc”) as they transition off the feather and into the gap.

Whip and Pause

E6010 electrodes require three specific manipulation techniques. To start, remember that voltage is proportional to distance. A long arc increases voltage (and puddle fluidity), and a short (“tight”) arc reduces voltage and provides more control over the puddle. Because of its driving arc characteristics, E6010 electrodes require a tight arc. Instructors sometimes tell students to basically push the electrode all the way into the gap (“You’re holding a long arc. Jam it in there!”).

The second and third techniques, known as “whip and pause” and “reading the key hole” must work in harmony. Instead of dragging the electrode at a consistent speed and angle or weaving it side to side, operators “whip” the electrode forward a fraction of an inch (perhaps 3/32 to 1/4 inch) and immediately bring it back about 1/8 inch and “pause” for a fraction of a second to build up the weld puddle.

Some experts describe the whip and pause motion as two steps forward, one step back; the distance of each step roughly equals the electrode diameter. Note that some operators don’t actually pause. Rather, they slowly move forward for about an electrode diameter before whipping again.

Whipping the electrode achieves several objectives. First, it gives the puddle a chance to cool, as well as provides operators with the ability to manipulate the puddle with a great degree of control. Second, it pulls the molten metal forward as the operator moves the electrode forward. Third, as the arc contacts new metal, it digs into the sides of the joint an opens up a keyhole.

Reading the Keyhole

When welding on open root joint and using the whip and pause technique, operators will notice a “keyhole” open up as they whip the rod forward (it’s called a keyhole because it looks like the hole on an old-fashioned lock). Good welding operators can read the keyhole and use it to judge heat input. In addition, they adjust their whip and pause technique, as well as travel speed, to control the size of the keyhole.

If the keyhole gets too large, the arc is in danger of blowing through the joint. To “save” the weld without breaking arc, solutions include increasing travel speed, holding the tightest arc possible and making a slight oval to push the heat onto the bevel. If that fails, stop welding and reduce amperage.

The Right Welder

E6010 electrodes require more voltage than other electrodes. Further, as operators whip the electrode, the arc length changes, and the welding power source needs to keep the arc established.

Because of these two issues, power sources good for running E6010 electrodes share two characteristics. First, they have a high open circuit voltage (OCV), which is voltage at the electrode before the arc is struck (e.g., no current being drawn). A frequent analogy is that OCV — and remember that voltage provides electrical pressure — is like a garden hose with the water turned on and before the nozzle is opened. A power source that provides good electrical pressure provides better arc starts.

Secondly, good E6010 welders have a large inductor. An inductor resists change in electric current passing through it. They are said to “hold power” or act as a “power reserve” to keep the arc established as the operator manipulates the electrode. Conventional power sources and welding generators use large magnetics, such as copper wire wrapped around a ferrite core. Inverter-based power sources use electronics and much smaller magnetics to minimize overall weight.

Note that inverters need to be specifically designed for welding with an E6010 electrode. Adding the required electronic components and writing the algorithms that provide good arc characteristics increases the cost of the unit. Most small multiprocess inverters designed to appeal more to the home-hobby welder simply don’t have these components (and the target audience doesn’t have the skill to run E6010 electrodes even if they did).

In other cases, as with the ESAB Rebel, the manufacturer specifically designed it to run E6010. When connected to 230 VAC it provides 92.8 VDC of OCV. Connected to 120 VAC, it provides 77.6 VDC of OCV. When welding, it’s rated Stick outputs are 110A/24.5V @ 20 percent duty cycle on 120 VAC and 160A/26.5V @ 20 percent duty cycle on 230 VAC.

As a result of good OCV and circuitry designed for E6010 electrodes, the Rebel provides mechanical contractors, pipe welders and other professionals with the type of arc control they commonly associate with a full industrial unit — in a 40-lb. package. Considering that most welders run a 1/8-inch diameter E6010 electrode at amperages between 70 and 100 amps (DC EN or EP), the Rebel provides a true portable solution for E6010 welding.

Most professional grade inverters also provide Adjustable Hot Start and Adjustable Arc Force control to tailor arc performance for specific electrodes. Hot Start increases current beyond the set value for a few milliseconds to help establish the arc. Because E6010

electrodes “light easily” (especially compared to E7018 electrodes), they do not need much Hot Start assistance; experiment with values of 0 to 15 percent. Arc Force control increases amperage when the voltage drops below a certain threshold, which enables operators to push the electrode into the joint without the electrode sticking. Because of their driving arc, E6010 electrodes do not need much additional Arc Force control; experiment with values of 10 to 30 percent.

Anyone who starts reading about Stick welding soon learns that the welding professionals who Stick weld on pipe, pressure vessels and other critical components stand in a league of their own when it comes to welding skills. One of the skills that sets them apart is their ability to repeatedly make “X-ray quality” welds with an E6010 electrode. To move from apprentice to Journeyman, welders put in thousands of hours of practice using industrial equipment. With the advances in lightweight inverters, these professionals now have another tool that simplifies work when portability matters. In addition, these inverters meet the needs of professionals who want a home welder that runs like their work system. And while the average Joe at home won’t run thousands of stringer beads in practice, at least there’s a unit that enables him to enjoy the benefits of E6010 electrodes.

-end-