

## How Polarity Affects Electrode Performance in Arc Welding

The term 'polarity' is used to describe the electrical connection of the electrode in relation to the terminal of a power source. With direct current (DC), when the electrode is connected to the positive terminal, the polarity is designated as direct current electrode positive (DCEP). When the electrode is connected to the negative terminal, the polarity is designated as direct current electrode negative (DCEN). When alternating current (AC) is used, the polarity changes every half cycle of 50 or 60 Hz.

### Why GMAW uses mostly DCEP

The vast majority of gas metal arc welding (GMAW) applications use DCEP. This condition yields a stable arc, smooth metal transfer, relatively low spatter, good weld bead characteristics and deep penetration for a wide range of welding currents. In contrast, with DCEN, the molten droplet size tends to increase and the droplet transfer becomes irregular, thereby increasing large grain spatter. However, some specific wires with unique chemical composition have been developed specifically for DCEN, which offers excellent performance on galvanized sheets. Attempts to use conventional AC have generally been unsuccessful due to the unstable arc in GMAW. However, state-of-the-art inverter and digital control technology have developed AC pulsed GMAW power sources for sheet metals.

### SMAW is the most versatile welding process in terms of polarity

The large variety of coating fluxes for covered electrodes enable the SMAW process to be the most versatile in terms of polarity. The majority of covered electrodes use either AC or DCEP. Some electrodes specifically E6013 (RB-26), E6019 (B-17) and E7024 (ZERODE-43F) offer good performance with AC, DCEP or DCEN. In contrast, high cellulose type electrodes such as E6010 (KOB-6010), E7010-P1 (KOB-7010S), and E8010-P1 (KOB-8010S) for pipe welding are designed for use with DCEP only for smoother droplet transfer. Low carbon type Cr-Mo electrodes such as E7015-B2L (CMB-95), and E8015-B3L (CMB-105) are also designed for use with DCEP

TIG welding uses DCEN for deep penetration in steels and AC for good electrode capacity and oxide cleaning action in aluminum alloys.



only, for better performance. Some specific electrodes such as LB-80UL for high strength steels and NB-1S for low temperature steels are recommended to use AC only in order to guarantee strict requirements for strength and impact toughness of weld metal in fabrication.

### How polarity affects SAW

The particular combination of wire and flux determines the choice of AC, DCEP or DCEN in SAW. With DCEP, the flux consumption ratio (the ratio of the amount of slag to the amount of deposited metal) is higher than with AC by roughly 10-30% depending on the type of flux. Consequently, the chemical composition - thus mechanical properties - of the weld metal can be affected by the polarity, although the degree of effect depends on the type of flux. This is why a careful choice of wire and flux combination is necessary taking into account the polarity of the power source to be used when the quality requirement for the weld metal is strict. **Table 1** shows an example of the effect of polarity on chemical composition and mechanical properties of weld metal. In these test results, marked differences are recognized in carbon, oxygen, 0.2% PS, TS and IV between AC and DCEP.

Table 1. An example of the effect of polarity in SAW using a fused type flux and solid wire for mild steel and 490N/mm<sup>2</sup> high strength steel (as-welded condition)

Polarity	C	Si	Mn	P	S	O
AC	0.07	0.30	1.61	0.017	0.005	0.067
DCEP	0.05	0.35	1.67	0.018	0.006	0.098
Polarity	0.2% PS (N/mm <sup>2</sup> )	TS (N/mm <sup>2</sup> )	El (%)	RA (%)	Av. IV at - 40 (J)	
AC	462	565	30	70	93	
DCEP	411	512	33	69	74	