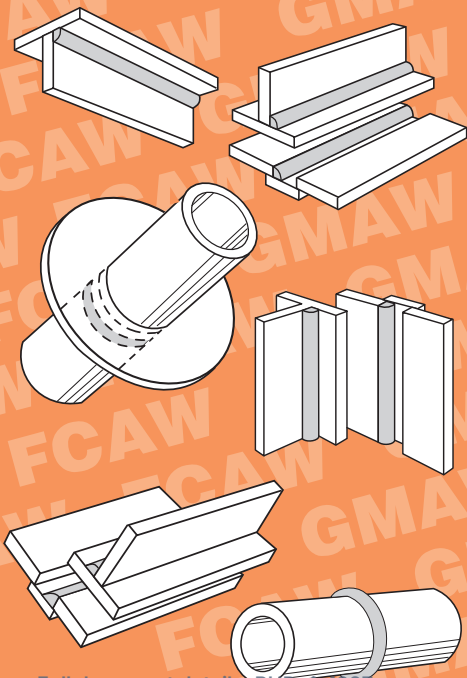




The Everyday Pocket Handbook for Gas Metal Arc Welding (GMAW) and Flux Cored Arc Welding (FCAW)



Number 4 in a series

Compiled as a useful tool for
on-the-job welding personnel by the
AWS Product Development Committee

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American Welding Society

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Basic Safety Precautions

Burn Protection. Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause burns if precautionary measures are not used. Workers should wear protective clothing made of fire-resistant material. Pant cuffs, open pockets, or other places on clothing that can catch and retain molten metal or sparks should not be worn. High-top shoes or leather leggings and fire-resistant gloves should be worn. Pant legs should be worn over the outside of high-top shoes. Helmets or hand shields that provide protection for the face, neck, and ears, and a head covering to protect the head should be used. In addition, appropriate eye protection should be used.

Electrical Hazards. Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. The manufacturer's instructions and recommended safe practices should be read and understood. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger.

All electrical equipment and the workpiece should be grounded. The workpiece lead is not a ground lead. It is used only to complete the welding circuit. A separate connection is required to ground the workpiece. The workpiece should not be mistaken for a ground connection.



Fumes and Gases. Many welding, cutting, and allied processes produce fumes and gases which may be harmful to health. Avoid breathing the air in the fume plume directly above the arc. Do not weld in a confined area without a ventilation system. Use point-of-welding fume removal when welding galvanized steel, zinc, lead, cadmium, chromium, manganese, brass, or bronze. Do not weld on piping or containers that have held hazardous materials unless the containers have been inerted properly.

Compressed Gas Cylinders. Keep caps on cylinders when not in use. Make sure that gas

cylinders are chained to a wall or other structural support.

Radiation. Arc welding may produce ultraviolet, infrared, or light radiation. Always wear protective clothing and eye protection to protect the skin and eyes from radiation. Shield others from light radiation from your welding operation.

Refer to AWS/ANSI Z49.1, *Safety in Welding and Cutting*, for additional information.

GMAW Filler Metal Specifications and Classification System

Material	Filler Metal		X Designator Description	Example
	AWS Spec.	AWS Class.*		
Steel, carbon	A5.18	ERXXS-Y EXXC-Y	Tensile strength $\times$ 1000 (psi)	ER70S-3 E70C-3
Steel, low alloy	A5.28	ERXXS-Y EXXC-Y	Tensile strength $\times$ 1000 (psi)	ER80S-B2 E80C-B2
Stainless steel	A5.9	ERXXX-Y	Stainless alloy (308, 410, etc.)	ER308L EC308L
Aluminum	A5.10	ERXXXX-Y	Aluminum alloy (4043, 5083, etc.)	ER4043
Nickel	A5.14	ERNiXX-Y	Major alloying elements (Cr, Fe, Mo, etc.)	ERNiCr-3
Copper	A5.7	ERCuXX-Y	Major alloying elements (Al, Ni, Si, etc.)	ERCuAl-A2
Magnesium	A5.19	ERXXYYY	Major alloying elements (Al, Zn, etc.)	ERAZ92A
Titanium	A5.16	ERTi-Y		ERTi-5

***Legend**

E — Filler metal may be used as an electrode

R — Filler metal may be used as a rod

S — Solid filler metal

C — Composite or stranded filler metal

Y — Designator (or combination of designators) that describe specific alloy, shielding gas to be used, diffusible hydrogen, etc. Refer to the appropriate AWS Filler Metal Specification shown in table for explanation.

GMAW Shielding Gases for Spray Transfer

Metal	Shielding Gas	Thickness	Advantages
Aluminum	100% Argon	0 to 1 in. (0 to 25 mm)	Best metal transfer and arc stability, least spatter
	65% Argon + 35% Helium	1 to 3 in. (27 to 76 mm)	Higher heat input than straight argon; improved fusion characteristics with 5XXX series Al Mg alloys
	75% Helium + 25% Argon	Over 3 in. (76 mm)	Highest heat input; minimizes porosity
Magnesium	100% Argon		Excellent cleaning action
Steel carbon	Argon + 3 to 5% Oxygen		Improves arc stability; produces a more fluid and controllable weld puddle; good coalescence and bead contour; minimizes undercutting; permits higher speeds than pure argon
	Argon + 8 to 10% Carbon Dioxide		High speed mechanized welding; low cost manual welding
Steel low alloy	98% Argon + 2% Oxygen		Minimize undercutting, provides good toughness

GMAW Shielding Gases for Spray Transfer (Continued)

Metal	Shielding Gas	Thickness	Advantages
Steel stainless	99% Argon + 1% Oxygen		Improves arc stability; produces a more fluid and controllable weld puddle; good coalescence and bead contour; minimizes undercutting on heavier stainless steels
	98% Argon + 2% Oxygen		Provides better arc stability, coalescence, and welding speed than 1 percent oxygen mixture for thinner stainless steel materials
Nickel, copper, and their alloys	100% Argon	Up to 1/8 in. (3.2 mm)	Provides good wetting; decreases fluidity of weld material
	Argon + Helium mixtures		Higher heat inputs of 50 and 75 percent helium mixtures offset high heat dissipation of heavier gases
Titanium	100% Argon		Good arc stability; minimum weld contamination; inert gas backing is required to prevent air contamination on back of weld area

GMAW Shielding Gases for Short Circuiting Transfer

Metal	Shielding Gas	Thickness	Advantages
Carbon steel	75% Argon + 25% Carbon Dioxide	Less than 1/8 in. (3.2 mm)	High welding speeds without burn through; minimum distortion and spatter
	75% Argon + 25% Carbon Dioxide	More than 1/8 in. (3.2 mm)	Minimum spatter; clean weld appearance; good puddle control in vertical and overhead positions
	50% Argon + 50% Carbon Dioxide		Deeper penetration; faster welding speeds
Stainless steel	90% Helium + 7.5% Argon + 2.5% Carbon Dioxide		No effect on corrosion resistance; small heat affected zone; no undercutting; minimum distortion
Low alloy steel	60 to 70% helium + 25 to 35% Argon + 4.5% Carbon Dioxide		Minimum reactivity; excellent toughness; excellent arc stability, wetting characteristics, and bead contour; little spatter
	75% Argon + 25% Carbon Dioxide		Fair toughness; excellent arc stability, wetting characteristics, and bead contour; little spatter
Aluminum, copper, magnesium, nickel, and their alloys	Argon and Argon + Helium mixtures	Over 1/8 in. (3.2 mm)	Argon satisfactory on sheet metal; argon helium preferred base material

Globular-to-Spray Transition Currents for a Variety of Electrodes

Wire Electrode Type	Wire Electrode Diameter		Shielding Gas	Minimum Spray Arc Current, A
	in.	mm		
Mild steel	0.030	0.8	98% Argon + 2% Oxygen	150
	0.035	0.9	98% Argon + 2% Oxygen	165
	0.045	1.1	98% Argon + 2% Oxygen	220
	0.062	1.6	98% Argon + 2% Oxygen	275
Stainless steel	0.035	0.9	98% Argon + 2% Oxygen	170
	0.045	1.1	98% Argon + 2% Oxygen	225
	0.062	1.6	98% Argon + 2% Oxygen	285
Aluminum	0.030	0.8	Argon	95
	0.045	1.1	Argon	135
	0.062	1.6	Argon	180
Deoxidized copper	0.035	0.9	Argon	180
	0.045	1.1	Argon	210
	0.062	1.6	Argon	310
Silicon bronze	0.035	0.9	Argon	165
	0.045	1.1	Argon	205
	0.062	1.6	Argon	270



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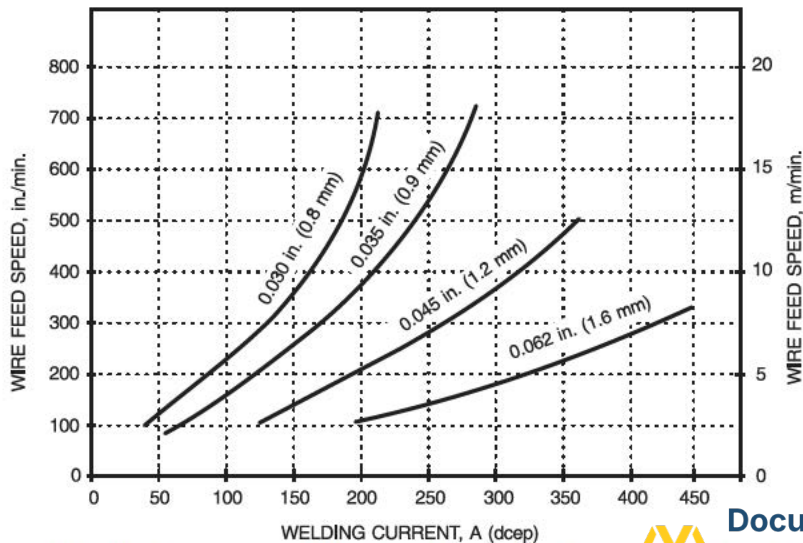
See page 11 for voltage settings.

Typical Arc Voltages for GMAW of Various Metals^a

Metal	Spray ^b Globular Transfer 1/16 in. (1.6 mm) Diameter Electrode					Short Circuiting Transfer .035 in (0.9 mm) Diameter Electrode			
	Argon	Helium	25% Ar + 75% He	Ar + 1 to 5% O ₂	CO ₂	Argon	Ar + 1 to 5% O ₂	75% Ar + 25% CO ₂	CO ₂
Aluminum	25	30	29			19			
Magnesium	26		28			16			
Carbon steel				28	30	17	18	19	20
Low alloy steel				28	30	17	18	19	20
Stainless steel	24			26		18	19	21	
Nickel	26	30	28			22			
Nickel copper alloy	26	30	28			22			
Nickel chromium iron alloy	26	30	28			22			
Copper	30	36	33			24	22		
Copper nickel alloy	28	32	30			23			
Silicon bronze	28	32	30	28		23			
Aluminum bronze	28	32	30			23			
Phosphor bronze	28	32	30	23		23			

a. Plus or minus approximately ten percent. The lower voltages are normally used on light material and at low amperage, the higher voltages are used on heavy material at high amperage.

b. For the pulsed variation of spray transfer the arc voltage would be from 18 to 28 volts depending on the amperage range used.



Typical Welding Currents vs. Wire Feed Speeds for Carbon Steel Electrodes

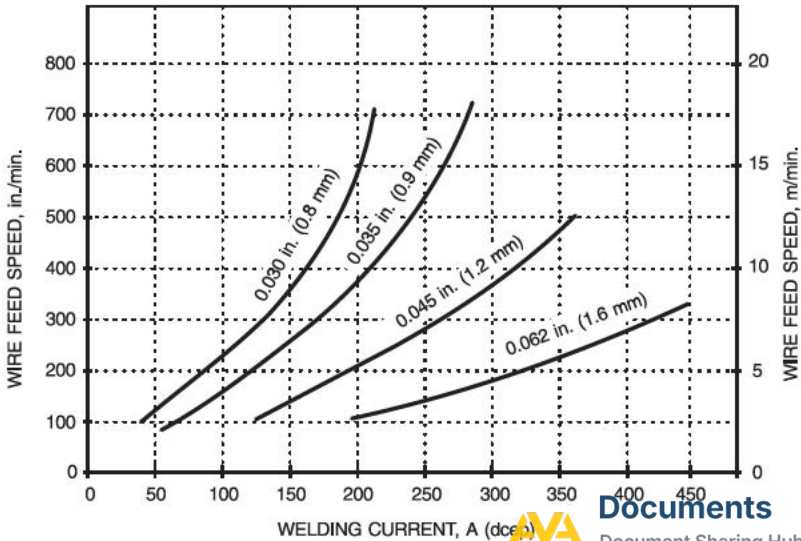


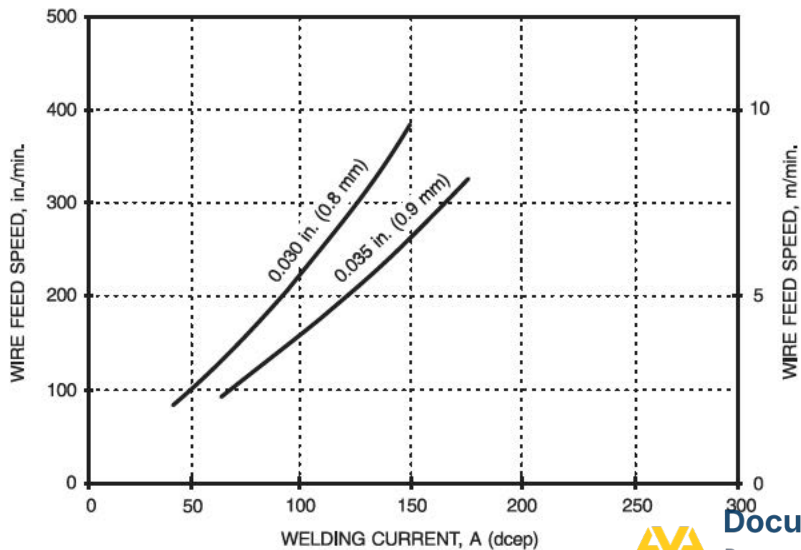
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Example:

To find the melting rate for 0.045 in. carbon steel wire at a wire feed speed of 350 inches per minute, draw a line from 350 on the top scale down to the 0.045 in. curve (line); then draw a line from that intersection left to the Melting Rate scale and read 10.2 pounds per hour (lb/h).

**Typical Melting Rates for Carbon Steel Electrodes**

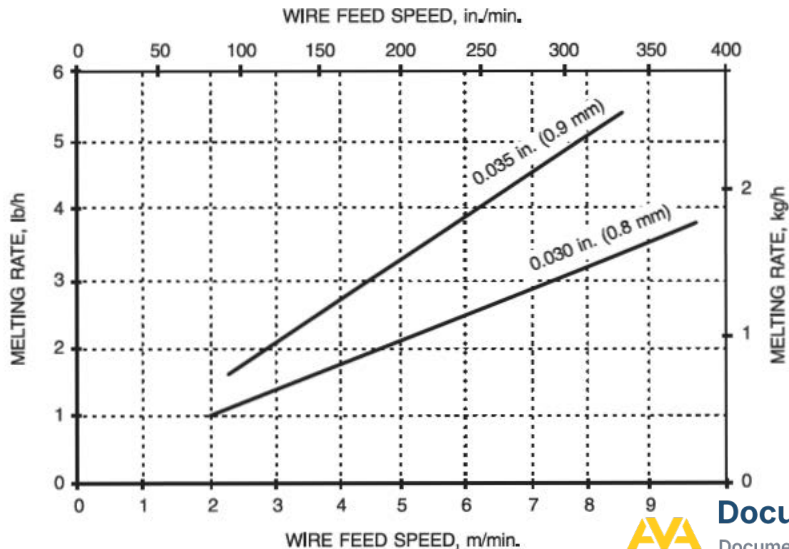


Typical Currents vs. Wire Feed Speeds Carbon Steel—Short Circuiting Arc



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Typical Melting Rates—Carbon Steel—Short Circuiting Arc



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