



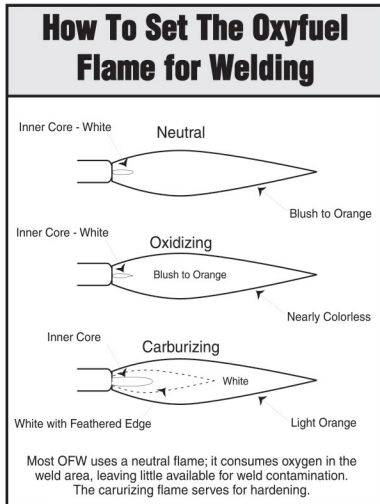
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G A S W E L D I N G

Welding - Oxyacetylene - Welding Parameters					
Tip	Drill	Oxygen pressure, lb/in ²	Acetylene pressure, lb/in ²	Acetylene Consumption, ft ³ /h*	Basemetal thickness, in
000	75	1/2-2	1/2-2	1/2-3	to 1/32
00	70	1-2	1-2	1-4	1/64-3/64
0	65	1-3	1-3	2-6	1/32-5/64
1	60	1-4	1-4	4-8	3/64-3/32
2	56	2-5	2-5	7-13	1/16-1/8
3	53	3-7	3-7	8-36	1/8-3/16
4	49	4-10	4-10	10-41	3/16-1/4
5	43	5-12	5-15	15-59	1/4-1/2
6	36	6-14	6-15	55-127	1/2-3/4
7	30	7-16	7-15	78-152	3/4-1 1/2
8	29	9-19	8-15	81-160	1 1/4-2
9	28	10-20	9-15	90-166	2-2 1/2
10	27	11-22	10-15	100-169	2 1/2-3
11	26	13-24	11-15	106-175	3-3 1/2
12	25	14-28	12-15	111-211	3 1/2-4

Oxygen consumption is 1.1 times that of acetylene under neutral flame conditions. Gas consumption will vary depending on the material being welded and operator skill. Pressures are approx. for hose length up to 25 ft. Increase for longer hose lengths, about 1 lb/in² per 25 ft.



CUTTING - Parameters for Oxyfuel Cutting													
Material Thickness, In.	1/8	1/4	1/2	3/4	1	1-1 1/2	2	4	5	6	8	10	12
Recommended Tip Number	00	0	1	1	2	2	3	3	4	6	6	7	8
Oxygen Pressure Setting, lb/in ² g	20-25	25-30	30-35	35-40	35-40	40-45	40-45	40-45	45-55	45-55	45-55	45-55	45-55
Acetylene Pressure Setting, lb/in ² g	3-5	3-5	3-5	3-5	3-7	3-7	5-10	5-10	6-12	7-13	8-14	10-15	10-15
Cutting Speed Range, in/min	27-30	26-29	20-24	17-21	14-18	13-17	12-15	8-11	7-9	6-8	5-6	4-5	3-4

S T I C K W E L D I N G

Covered Electrodes for SMAW of Carbon Steel per AWS A5.1					Arc Welding Processes - SMAW
Classification	Covering	Weld Position	Current	Characteristics, applications	
E6010	High-Cellulose sodium	F, V, O, H	dcep	A general purpose electrode for joining carbon steel. Deep-penetrating forceful arc. Thin slag. Used in all positions single and multiple pass, plate and pipe. galvanized and alloy steels. Ships, bridges, buildings, piping, tanks, pressure-vessel fittings.	
E6011	High-Cellulose potassium	F, V, O, H	ac, dcep	Similar to E6010, but for use with ac. Dcep gives reduced penetration.	
E6012	High-Titania sodium	F, V, O, H	ac, dcen	Dense slag that covers the bead, low-penetrating arc. Used to bridge joints with poor fitup. Fillets have smooth, convex face. Runs well at amps higher than E6010/E6011.	
E6013	High-Titania potassium	F, V, O, H	ac, dcen, dcep	Similar to E6012; Quieter arc, smoother bead, cleaner weld metal, fewer inclusions. Characteristics vary with supplier. Run at lower current than for E6012.	
E6022	High Iron Oxide	F	ac, dcep, dcen	Use for single-pass, high-current, high-speed welding of groove welds in flat position, horizontal lap joints and fillet welds in sheet metal.	
E6027	High Iron Oxide, Iron Powder	H-Fillets, F	ac, dcep	For fillets of groove welds, flat position, heavy slag, good side wall fusion. Use at high amperage on thick plate.	
E7014	Iron Powder, Titania	F, V, O, H	ac, dcep	Iron powder boosts deposition rate and efficiency. Use at high amperages on carbon and low-alloy dcn steels. Low-penetrating arc, use to bridge poor fitups. Smooth, fine-rippled bead, convex fillets.	
E7018, 7018-1, 7018R, 7018-1R, 7018H16, H8, H4	Low-Hydrogen potassium, iron powder	F, V, O, H	ac, dcep	Iron-powder addition increases deposition rate. Use on carbon, high-carbon, and low-alloy steels. Smooth arc, low spatter. Flat and horizontal welds are finely rippled, convex. Other types: E7018-1H16R, E7018-1H8R, E7018-1H4R.	
E7018M	Low-Hydrogen iron powder	F, V, O, H	dcep	Yield strength, 53000-72000 lb/in. Ductility high, extra impact strength and compositional limits and limits on moisture and hydrogen. Similar to E7018-1H4R, MIL-7018-M. Characteristics similar to E7018.	
E7024, E7024-1	Iron Powder, Titania	H-Fillets, F	ac, dcep, dcen	Iron powder for high deposition rate, high travel speed. Flat, smooth fillets, finely rippled. Smooth quiet arc, low penetration. E7024-1 deposits more ductile weld metal of improved charpy values.	

Recommended Amperages For Electrodes by Type and Diameter Current Range, A									
Electrode Diameter (in.)	Electrode Type								
	6010, 6011	6012	6013	6020	6027	7014	7015, 7016	7018	7024, 7028
1/16	--	20-40	20-40	--	--	--	--	--	--
5/64	--	25-60	25-60	--	--	--	--	--	--
3/32	40-80	35-85	45-90	--	--	80-125	65-110	70-100	100-145
1/8	75-125	80-140	80-130	100-150	125-185	110-160	100-150	115-165	140-190
5/32	110-170	110-190	105-180	130-190	160-240	150-210	140-200	150-220	180-250
3/16	140-215	140-240	150-230	175-250	210-300	200-275	180-255	200-275	230-305
7/32	170-250	200-320	310-300	225-310	250-350	260-340	240-320	260-340	275-365
1/4	210-320	250-400	250-350	275-375	300-420	330-415	300-390	315-400	335-430
5/16	275-425	300-500	320-430	340-450	375-475	390-500	375-475	375-470	400-525

T I G W E L D I N G

Tungsten Electrodes for GTAW - Selection Guide				
Base Alloy	Thickness	Current	Electrode	
Aluminum	All Thick Thin	ac dcen dcep	Pure, Zirconium Thoriated Thoriated, EWZr	
Copper and Copper Alloys	All Thin	dcen ac	Thoriated Pure, Zirconium	
Magnesium Alloys	All Thin	ac dcep	Pure, EWZr, Thoriated	
Nickel and Nickel Alloys	All	dcen	Thoriated	
Plain Carbon and Low-Alloy Steel	All Thin	dcen ac	Thoriated Pure, EWZr	
Stainless Steel	All Thin	dcen ac	Thoriated Pure, EWZr	
Titanium	All	dcen	Thoriated	

Current Ranges for Tungsten Electrodes (Argon Shielding Gas)										
Electrode Diameter (inches)	Dcen, A			Dcep, A			High-Frequency unbalanced ac, A		High-Frequency balanced ac, A	
	EWP	EWTh-1	EWTh-2	EWP	EWTh-2	EWTh-3	EWP	EWTh-1	EWTh-2	EWTh-3
0.010	up to 15	--	--	up to 15	up to 15	--	up to 15	up to 15	--	--
0.020	5-20	--	--	5-15	5-20	--	10-20	5-20	10-20	10-20
0.040	15-80	--	--	10-60	15-80	10-80	20-30	20-60	20-60	20-60
1/16	70-150	--	--	10-20	50-100	70-150	50-150	30-80	60-120	30-120
3/32	150-250	--	--	15-30	100-160	140-235	100-235	60-130	100-180	60-180
1/8	250-400	--	--	25-40	150-210	225-325	150-325	100-180	160-250	100-250
5/32	400-500	--	--	40-55	200-275	300-400	200-400	160-240	200-320	160-320
3/16	500-750	--	--	55-80	250-350	300-500	250-500	190-300	290-390	190-390
1/4	750-1000	--	--	80-125	325-450	400-630	325-630	250-300	340-525	250-525

Filler Alloys for Welding of Wrought Aluminum Alloys														
Base Alloy, Type	6070	6061 6030, 6101 6201, 6151 6351, 6951	5456	5454	5154 5254	5086	5083	5052 5652	5005 5050	3004 Alc. 3004	2219 2519	2014 2036	1100 3003 Alc. 3003	1060 1070, 1080 1350
1060, 1070, 1080, 1350	4043	4043	5356	4043	4043	5356	5356	4043	1100	4043	4145	4145	1100	1188
1100, 3003, Alcaid 3003	4043	4043	5356	4043	4043	5356	5356	4043	1100	4043	4145	4145	1100	
2014, 2036	4145	4145												
2219, 2519	4043	4043	4043	4043	4043	4043	4043	4043	4043	4043	2319			
3004														
Alcaid 3004	4043	4043	5356	5654	5654	5356	5356	4043	4043	4043				
5005, 5050	4043	4043	5356	5654	5654	5356	5356	4043	4043					
5052, 5652	5356	5356	5356	5654	5654	5356	5356							
5083	5356	5356	5183	5356	5356	5356	5183							
5086	5356	5356	5356	5356	5356	5356								
5154, 5254	5356	5356	5356											
5454	5356	5356	5356											
5456	5356	5356	5356											
6061, 6063, 6351, 6101, 6201, 6151, 6951	4043	4043												
6070	4043													

Stainless Steels - Filler Metals for Welding Dissimilar Steels																		
Base Alloy, Type	201, 202, 301, 302, 302B, 303, 304, 305, 308	304L	309	310	316	316L	317	317L	321, 347, 348	330	403, 405, 410, 412, 440C	430, 430F, 431, 440A, 440B, 440C	446	501, 502	505	Carbon Steels	Cr-Mo Steels	
201, 202, 301, 302, 302B, 303, 304, 305, 308	E308		E308	E308	E308	E308	E308	E308	E308	E309	E309	E309	E309	E310	E309	E309	E309	
304L		E308L	E308	E308	E308	E308	E308	E308	E308	E309	E309	E309	E309	E310	E309	E309	E309	
309, 309S			E309	E309	E309	E309	E309	E309	E309	E309	E309	E309	E309	E310	E309	E309	E309	
310, 310S, 314				E310	E316	E316	E317	E317	E308	E310	E309	E309	E310	E310	E310	E310	E309	
316					E316	E316	E316	E316	E308	E309	E309	E309	E310	E310	E310	E310	E309	
316L						E316L	E316L	E316L	E316L	E309	E309	E309	E310	E310	E310	E310	E309	
317							E317	E317	E308	E309	E309	E309	E310	E310	E310	E310	E309	
317L								E317L	E308L	E309	E309	E309	E310	E310	E310	E310	E309	
321, 347, 348									E347	E309	E309	E309	E310	E310	E310	E310	E309	
330										E330	E309	E309	E310	E312	E312	E312	E312	
403, 405, 410, 414, 416, 420												E410	E430	E410	E502	E505	E309	
430, 430F, 431, 440A, 440B, 440C													E430	E430	E502	E505	E430	
446														E446	E502	E502	E430	
501, 502															E502	E502	E502	
505																E505	E505	



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M I G W E L D I N G

Shielded Gases for GMAW			
Base Metal	Thickness, in.	Shielded Gas	Advantages
GMAW-Short-Circuit Transfer			
Carbon Steel	Up to 14 gage	Argon-8 CO ₂	Good burnthrough and distortion control. Used also for spray-arc-welding.
	14 gage-1/8	Argon-25 CO ₂	High welding speeds without burnthrough. Minimum distortion and spatter. Best puddle control for out of position welding. Provides best mechanical properties for any given wire.
	Over 1/8	Argon-25 CO ₂	High welding speeds without burnthrough. Minimum distortion and spatter. Best puddle control for out of position welding. Provides best mechanical properties for any given wire.
	Over 1/8	50 Argon-50 CO ₂	Deep penetration; low spatter.
	Over 1/8	CO ₂	Deep penetration; faster welding speeds.
Stainless Steel	Up to 14 gage	Ar-8 CO ₂	Good burnthrough and distortion control.Used also for spray arc welding.
	Over 14 gage	Ar-25 CO ₂	For use where corrosion resistance is not mandatory.
	Over 14 gage	Ar-CO ₂ -HE	No effect on corrosion resistance. Small heat affected zone. No undercutting. Minimum distortion. Good bead shape and mechanical properties.
High-yield strength steels	Up to 14 gage	Argon-8 CO ₂	Good burnthrough and distortion control. Used also for spray arc welding.
	Over 14 gage	Ar-CO ₂ -HE	Excellent arc stability, welding characteristics, bead contour. Little spatter. High impacts.
GMAW-Spray Transfer			
Carbon Steel	All	Argon-5 CO ₂	Improves droplet rate and stability.
		Argon-8 CO ₂	Produces a fluid, controllable weld puddle; good coalescence and bead contour. Minimizes undercutting; Permits higher speeds.
		Argon-25 CO ₂	Suitable for high current welding.
Low-alloy Steel	Up to 3/32	Argon-2 O ₂	Reduces undercutting, improves coalescence and bead contour. Good mech. properties.
	Over 3/32	Argon-8 CO ₂	Excellent arc and weld characteristics.
Stainless Steel	All	Argon-1 CO ₂	Good arc stability. Produces a fluid and controllable weld puddle; good coalescence and bead contour. Minimizes undercutting.
		Argon-2 O ₂	Can be used on the more sluggish alloys to improve puddle fluidity, coalescence and bead contour.

GMA Welding Parameters - Stainless Steel						
Base material thickness In.	Wire-Feed speed, In./min, 0.035-in.	Voltage, v				
		75-Ar 25 CO ₂	90 He-7.5 Ar-2.5CO ₂	Ar	98-Ar 2 O ₂	Current, A
0.048	120-150	16	19.7	--	--	50-60
0.060	180-205	17	20	--	--	70-80
0.075	230-275	17.7	20.5	--	--	90-110
0.10	300-325	18	20.7	20	--	120-130
3/16	350-375	18.5	20.7	20.5	--	140-150
1/4	400-425	19	21.2	21.5	23.5	160-170
5/16	450-475	19.5	21.5	22.5	24.5	180-190
3/8	Use 0.045	20.2	--	23.5	25	200-210
7/16	Use 1/16	22	--	25	26.5	220-250
1/2 Up	--	26	--	29	31	300

Solid Wires for GMAW of Carbon Steel per AWS A5.18								
Classification	Composition						Characteristics	Applications
	C	Mn.	Si	Ti	Zr	Al		
ER70S-2	0.07	0.90-1.40	0.40-0.70	0.05-0.15	0.02-0.12	0.15-0.15	Contains Ti, Zr, Al deoxidants in killed, semi-killed, and rimmed steels. Use on rusted, dirty steel; Ar-O ₂ CO ₂ Ar-CO ₂ shielding. For out-of-position short circuit transfer.	Structural steelwork, pipe, offshore platforms, Automobile frames.
ER70S-3	0.06-0.15	0.90-1.40	0.45-0.70	--	--	--	For single-pass welds, multipass on killed or semikilled steel. CO ₂ , Ar-O ₂ shielding. Small diameters for out-of-position welding, short-circuit transfer with CO ₂ , Ar-CO ₂ shielding. High heat input with CO ₂ degrades mechanical properties. Weld puddle more fluid than with ER70S-2, for better wetting, flatter bead.	General-purpose fabrication, heavy equipment, metal furniture, automotive frames pipe and vessel root passes, hvac ductwork.
ER70S-6	0.07-0.15	1.40-1.80	--	--	--	--	Highest Mn-Si content, for high current welding with CO ₂ of killed, semikilled, rimmed steels, moderate surface scale. Welds out-of-positions, short-circuit transfer. Smooth welds on sheet metal. Good for poor fittups. Short-arc with CO ₂ or Ar-CO ₂ .	Structural steel work, tanks, heavy equipment.

M I S C . W E L D I N G

Decimal/Wire Gauge/Metric Equivalents			
Inch (Fract.)	SWG Size	Decimal (Thsndths)	Millimeters
1/64	25 and 23	.0156	0,5 - 0,6
1/32	22 and 21	.0312	0,7 - 0,8
3/64	18	.0468	1 - 1,2
1/16	16	.0625	1,5 - 1,6
5/64	14	.0781	2
3/32	12	.0937	2,4 - 2,5
1/8	10	.1250	3 - 3,2 - 3,25
5/32	8	.1562	4
3/16	6	.1875	4,8 - 5
1/4	4	.2500	6
17/64	2	.2656	6 - 8
5/16	0	.3125	8
25/64	4/0	.3906	10
15/32	6/0	.4687	12
19/32	--	.5937	15

Recommended Guide for Shade Numbers				
Operation	Electrode Diameter inches	Arc Current, Amps	Minimum Protective Shade	Recommended Shade Number
Shielded Metal Arc	<3	<60	7	--
	3-5	60-160	8	10
	5-8	160-250	10	12
	>8	250-550	11	14
Gas-Metal-Arc Welding	<3	<60	7	--
	3-5	60-160	10	11
	5-8	160-250	10	12
	>8	250-500	10	14
Gas-Tungsten-Arc	<3	<50	8	10
	3-5	50-150	8	12
Air-Carbon Arc Cutting	<3	<500	10	12
	3-5	500-1,000	11	14
Plasma-Arc Welding	<3	<20	6	6-8
	3-5	20-100	8	10
	5-8	100-400	10	12
	>8	400-800	11	14
Plasma-Arc Cutting	<3	<300	8	9
	3-5	300-400	9	12
	5-8	400-800	10	14
Torch Brazing				3-4
Torch Soldering				2
Carbon Arc Welding				14
Oxyfuel Welding	Plate Thickness			
	<1/8			4-5
	1/8-1/2			5-6
	>1/2			6-8
Oxyfuel Cutting	<1			3-4
	1-6			4-5
	>6			5-6

Arc Carbon Current Requirements									
Inch mm	Electrode Size								
	1/8 3.2	5/32 3.97	3/16 4.76	1/4 6.5	5/16 7.94	3/8 9.5	1/2 12.7	3/8 9.5	5/8 15.88
Min DC	60	90	200	300	350	450	800	250	300
Max DC	90	150	250	400	450	600	1000	450	500
Min AC	--	--	200	300	325	350	--	--	--
Max AC	--	--	250	400	425	450	--	--	--

Recommended Sizes for Copper Welding Cable						
Welding Equipment output, A	Duty Cycle	Cable sizes (AWG) for combined lengths of electrode and ground cables, feet				
		0-50	50-100	100-150	150-200	200-250
100	20	8	4	3	2	1
180	20-30	4	4	3	2	1
200	60	2	2	2	1	1/0
200	50	3	3	2	1	1/0
250	30	3	3	2	1	1/0
300	60	1/0	1/0	1/0	2/0	3/0
400	60	2/0	2/0	2/0	3/0	4/0
500	60	2/0	2/0	3/0	3/0	4/0
600	60	2/0	2/0	3/0	4/0	Two-3/0