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An Approach to Best Welding Practice. Part – XXI – Section III – B-I

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"AN APPROACH TO BEST WELDING PRACTICE. Part – XXI-B" is the Twenty First Detail Part of "AN APPROACH TO BEST WELDING PRACTICE" which was written as a General and Overall approach to the subject matter.

AN APPROACH TO BEST WELDING PRACTICE. Part – XXI., Section III - B-I is particularly focused on the Generation and Computer based Storage of Welding Data on Gas Metal Welding (GMAW) Processes for Fabrication. It is required as a Working Guideline for Planning Engineers, Welding Coordinators and Quality Managers working in an Engineering Fabrication Plant using welding as the main manufacturing process.

In fact, this is a lengthy process to develop and as each and every step is connected with each other for cross references, none can be eliminated.

In every Fabrication concern where Welding is the major manufacturing process preparation, recording and storage of welding processes must be done.

Which Data are needed ?

It is understood and accepted that in Fabrication and manufacturing Industries where Welding is the main process, classification of Data used and needed is very difficult. We can at best identify the following needs

1. Welding processes
2. Welding Power Sources with Ancillary Equipment
3. Consumables – Electrodes, Wires, Flux Cored Wires
4. Shielding Gases
5. Joint design weldment design and surface preparation
6. Weld location Welding position

How to store and retrieve data ?

A large number of computer softwares have been developed to store data, modify and to retrieve as and when required. This system will eliminate human error, can link and compare past performances with the present one instantly, may even point out optimum use of resources for increased efficiency, effectiveness of resources for ultimate gain of productivity and quality improvement.

An integrated system will include:

* Filler and base metals and their chemical and mechanical properties;
* Histories of welder qualification and the quality of welds by each welder;
* Welding-procedure information, including WPSs, PQRs, and pre- and post weld heat-treatment information;
* Design information, including joint design graphics and welding symbol information; Corrosion-resistant and wear-resistant material information, such as ferrite content and prediction for stainless steel welds.

The softwares art all designed to operate in the computing environment of the desktop computer, turning the computer into a welding engineering work station.

GMAW Circuit

This is the basic equipment used for a typical GMAW, semi-automatic setup. Included are:

- A welding machine which provides welding power
- A wire feeder which controls the supply of wire to the gun
- A supply of electrode wire
- A welding gun, which directs the electrode wire into the joint
- A shielding gas cylinder, which provides a supply of shielding gas to the arc area.

The reason for the term "circuit" is that there is an electrical circuit from the welding machine through the electrode lead to the wire feeder, from the wire feeder to the gun via an electrode lead, through the gun to the wire, then to the arc, through the arc to the workpiece, and back to the welding machine via the work lead.

Welding Machine

With the many types of welding machines available, certain

GMAW PROCESS

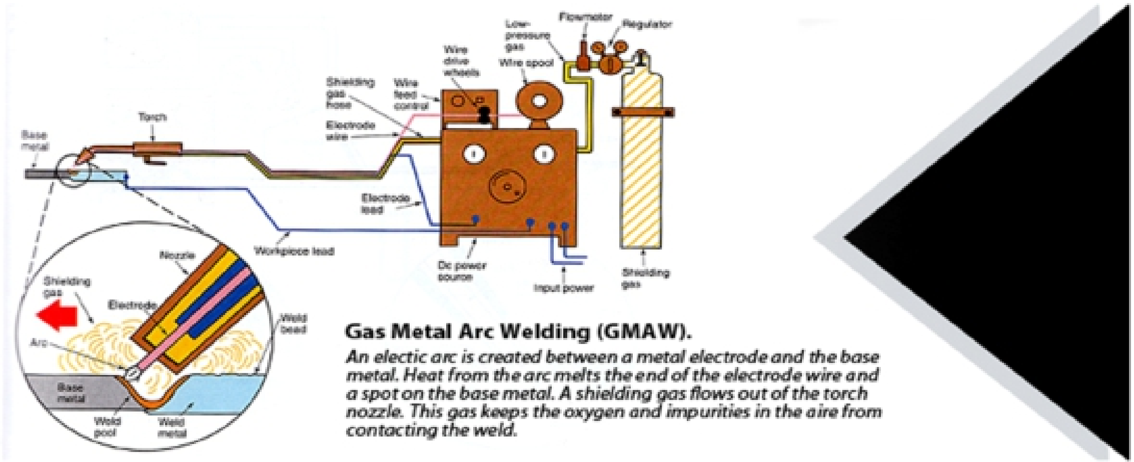


Fig. – I

considerations must me made in order to fit them right machine to the job:

- Mode of transfer needed? (Short circuit, Globular Transfer, Spray Arc Transfer)
- Output needed? (Voltage and Amperage)
- Duty cycle needed? (How often must the machine cool down?)
- Multi−process capability needed? (Changeable for constant voltage and constant amperage)
- Remote control needed? (Voltage can be adjusted some distance away from the machine)
- Portability needed?
- Primary power available? (115V, 230V, 380V)

Power Supply

Almost all GMAW welding is done with direct current (DC) reverse polarity. The primary source is normally either 230 V or 460 V AC current input power, which is changed by a rectifier unit to secondary circuit DC. The power source should be a constant voltage welding machine (CV). This contrasts with SMAW welding which use constant current (CC) power supplies.

A GMAW welding power supply provides a relatively constant voltage to the arc during welding. This voltage determines the arc length dependent to the current (amperage) being used. The welding current output depends on the wire−feed−speed, while the voltage output is adjusted by a voltage regulator.

When there is a sudden change in wire feed speed, or a momentary change in arc length, the power supply abruptly increases or decreases the current depending on the arc length change.

A 450mpi is a high performance constant voltage (CV) and constant current (CC) inverter power source designed to provide multi-process welding capabilities with dependability and ease of use.

The power source should operate on a 60% duty cycle with a load of 450 amperes at 34 V dc (with 3-phase input). Duty cycle is defined as the ratio of operating time to total time. Ratings are based on a 10- minute cycle. The 60% duty cycle rating means that the 450 ampere, 34 volt rated load can be applied for a total of 6 minutes and shut off for a total of 4 minutes in a 10 minute period. If the welding current (or voltage) is reduced, the duty cycle increases. Conversely, if the welding current (or voltage) is increased, the duty cycle will decrease.

Table – I : Rated output of a Power Source

100% Duty Cycle	(3 phase input)	300 A	@ 32 V dc
100% Duty Cycle	(1 phase input)	225 A	@ 29 V dc
60% Duty cycle	(3 phase input)	450 A	@ 34 V dc
Open-circuit Voltage (max) 70 V dc			

TABLE – II : Operational Features of Conventional GMAW Power Sources

Type of power source	How to adjust amperage and voltage	Operational feature
1. Thyristor type	(a) Welding current and arc voltage can be adjusted by controlling the knobs of the remote controller. (b) Many brands use only the A-V individual control, but some can also facilitate the -V automatic control by shifting the switch. (c) Many models for high welding currents facilitate the crater treatment control.	a) The remote controller facilitates continuous, non-tapped adjustment of welding current and arc voltage. (b) Welding current and arc voltage can be changed while the arc is generated. (c) Welding parameters can be set and changed by external electrical signals. This feature is suitable for automatic welding in uses of customized
2. Tapped transformer type	(a) Arc voltage can be adjusted by controlling the tap of the power source. (b) Welding current can be adjusted by controlling the adjusting knob. (c) Many models use the A-V individual control, and some	(a) Tapped adjustment of arc voltage is an easier operation. (b) Fine adjustment of arc voltage depends on the number of taps. (c) Welding parameters cannot be changed by external electrical signals and by the tap and knob while the arc is generated.
3. Sliding transformer type	(a) With many models using the A-V automatic control, welding current can be adjusted by controlling the lever of the power source. (b) Some models facilitate individual adjustment of welding current and arc voltage by using the lever for voltage and the knob for current of the power source.	(a) Turning the lever facilitates continuous adjustment of the output. (b) It is difficult to change welding parameters by external electrical signals. This is why most of the power sources are not equipped with a remote controller.

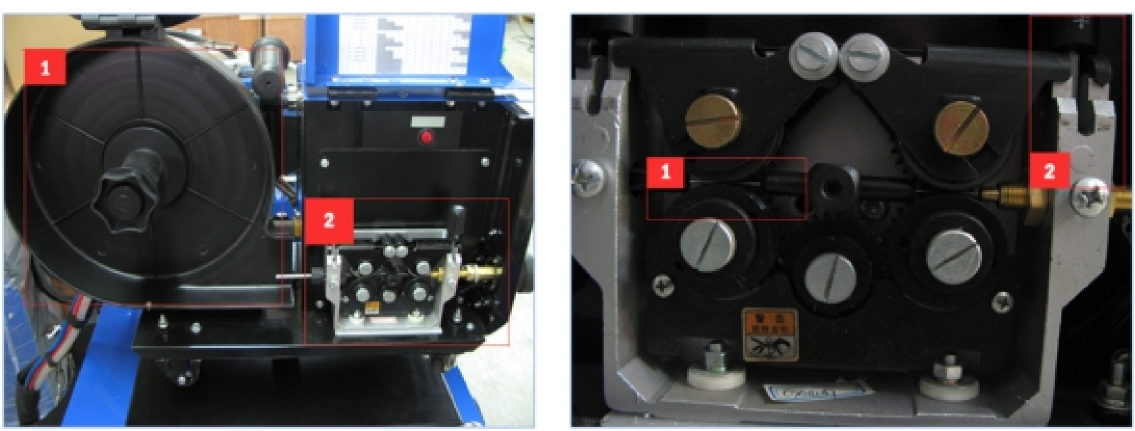


Fig. II : Wire Feeder

1. This is the spool of wire that feeds the welder. The wire 1. Wire being fed through the rollers comes off the spool, is pushed through the feeder and 2. Tensioning adjustment travels out to the welding torch.
2. These are the rollers that pull the wire off the spool and send it out to the welding torch

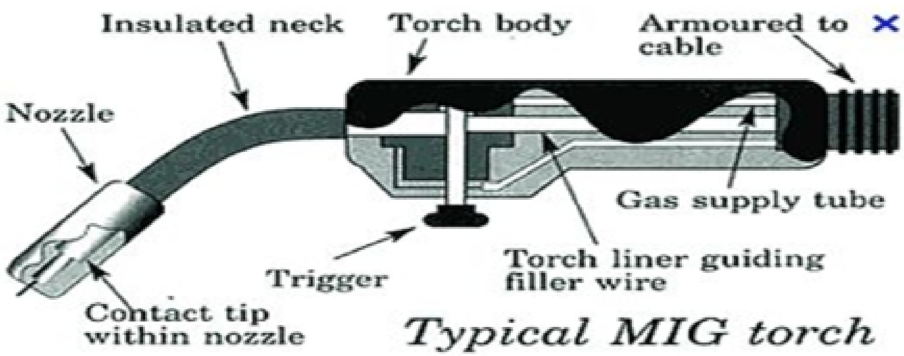
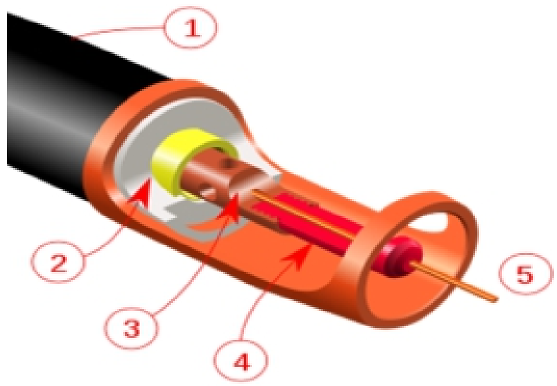


Fig. III : GMAW Gun



(1) Torch handle,

(2) Molded phenolic dielectric (shown in white) and threaded metal nut insert (yellow),

(3) Shielding gas diffuser,

(4) Contact tip,

(5) Nozzle output face

Fig. IV : Welding Torch

Table – III : Gun Nozzle Size & Gas Flow

MIG Gun Nozzle Size Inside Diameter	Minimum Suggested Flow	Typical Flow Setting	Maximum Suggested Flow
3/8 inch (For Access on Small Welders)	15 CFH	18-22 CFH	~ 30 CFH
1/2 inch (Typical on Small Welders)	18 CFH	22-27 CFH	~ 40 CFH
5/8 inch (Most Industrial Welders)	22 CFH	30-35 CFH	~ 55 CFH
3/4 inch (For Large Size Cored Wire)	30 CFH	30-40 CFH	~ 65 CFH

Gas Nozzle

Contact Tip	:	0.23 or 0.25
Liner	:	0.23 or 0.25
Wire	:	0.23 / 0.25 ER70S - 6
Shielding Gas	:	75% ARGON + 25 % CO_2
Polarity Setting	:	Reverse Polarity

Note: Tip, Liner, Wire & Rollers must be of same size

SHIELDING GASES

Table – IV : Comparison – Argon/helium.

PROPERTIES OF SHIELDING GAS

FUNCTION:

	ARGON	HELIUM
IONIZATION POTENTIAL	15.8 eV	24.6 eV
ARC INITIATION	GOOD	POOR
ARC STABILITY	GOOD	POOR
THERMAL CONDUCTIVITY (cal / sq.cm / cm ° C / s)	0.406×10^{-4}	3.32×10^{-4}
DENSITY (RELATIVE TO AIR)	1.38	0.137
CLEANING ACTION	GOOD	POOR

. Table – V : Properties Of Argon

Properties of Argon

Property	Description
Color	no color
Density	0.0017837 grams per cubic cm
Melting Point	minus 308.83 degrees Fahrenheit
Boiling Point	minus 302.53 degrees Fahrenheit
Conductivity	*not a good conductor *insulates well

Table – VI : Shielding Gas Selection Guide

Shielding Gas Selection Guide

CO_2	Argon-CO_2	Argon-O_2
Higher fume levels	Lower fume levels	Lowest fume levels
Deeper penetration	Shallower penetration	More rounded penetration
More violent or inconsistent arc transfer	Smoother arc transfer	Smoother arc transfer
Lower cost	Higher cost	Highest cost
Higher spatter	Lower spatter	Lowest spatter
Less radiated heat	More radiated heat	Most radiated heat
Less attractive beads	More attractive beads	More attractive beads
Pulse welding not possible	Pulse welding possible	Pulse welding possible
Spray transfer not possible	Spray transfer possible	Spray transfer possible

Table – VII : Gas Mix. & Weld Parameters

Gas	Wire Diameter	Amps	Volts	Wire Feed Speed m/min	Transfer Mode
Ar + O_2 + CO_2	1.0mm	152	22.5	7.8	Spray
	1.0mm	48	16.1	2.4	Pulsed
	1.0mm	83	16	3.6	Dip
Ar + He + CO_2	1.0mm	178	27	8.7	Spray
	1.0mm	50	17.9	2.9	Pulsed
	1.0mm	47	16.2	2.1	Dip
Ar + O_2	1.0mm	147	22	6.9	Spray
	1.0mm	49	15.9	2.5	Pulsed
	1.0mm	73	16.7	3.2	Dip

Table – VIII : Shielding Has Flow Pattern

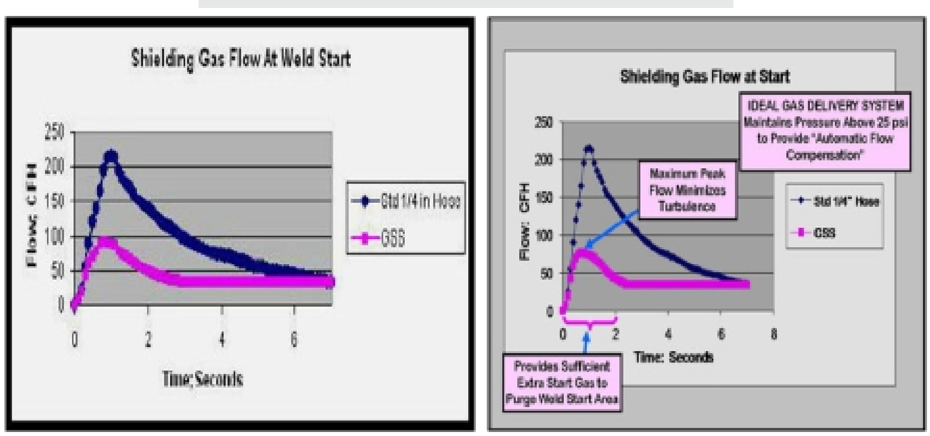


Table – IX : Gas Mix, Weld Parameters for Carbon Steel and Stainless Steels

Base Metal	Shielding Gas	Advantages
Carbon steels	75 % Ar-25 % CO_2 Ar + 25-50 % CO_2 CO_2	Less than 1/8 in. (3.2 mm) thick: high welding speeds without melt through; minimum distortion and spatter. More than 1/8 in. (3.2 mm) thick: minimum spatter, clean weld appearances, good puddle control in out of position welding. Deeper penetration and faster welding speeds.
Low-alloy steel	60-70 % He +25-35 % Ar +4-5 % CO_2 75 % Ar+25 % CO_2	Minimum reactivity; excellent toughness, arc stability, wetting characteristics and bead contour; little spatter. Fair toughness; excellent arc stability, wetting characteristics and bead contour; little spatter.
Stainless steels	90 % He+7.5 % Ar +2.5 CO_2	No effect on corrosion resistance; small HAZ; no undercutting; minimum distortion.
Aluminium, Copper, Magnesium, Nickel and their alloys.	Ar & Ar-He mixtures	Argon satisfactory on thin sections; argon helium mixtures preferred on thicker materials.

Carbon Steel With 75 Percent Argon/25 Percent CO_2 Shielding Gas

Thickness (ga.)	Wire Diameter (inch)	Wire Feed Speed (IPM)	Current (amps)	Voltage
24	0.023	140-170	40-50	14-15
24	0.030	110-120	45-50	13-14
20	0.030	125-135	55-60	13-14
20	0.035	105-115	50-60	15-16
18	0.035	140-160	70-80	16-17
16	0.035	180-220	90-110	17-18
16	0.045	90-110	90-110	17-18
14	0.035	240-260	120-130	17.5-18
10	0.035	280-300	140-150	18-19
10	0.045	140-150	140-150	18-19
3/16	0.035	320-340	160-170	18.5-19.5
3/16	0.045	160-175	160-170	18.5-19.5

Stainless Steel With 90 Percent Helium/7.5 Percent Argon/2.5 Percent CO_2

Thickness (ga.)	Wire Diameter (inch)	Wire Feed Speed (IPM)	Current (amps)	Voltage
18	0.030	130-160	30-40	15-16.5
18	0.035	105-115	50-60	18-18.5
16	0.035	140-160	70-80	18-19
14	0.035	180-220	90-110	18.5-19
14	0.045	90-110	90-110	18.5-19
10	0.035	240-260	120-130	19-20
10	0.045	120-130	120-130	19-20
3/16	0.035	280-300	140-150	19-20
3/16	0.045	140-150	140-150	19-20

Table – X : Material Thickness & Weld Parameters

MATERIAL THICKNESS (inches)	ELECTRODE SIZE	WELDING DCRO (arc volts)	CONDITIONS (amperes)	GAS FLOW (cfh)	TRAVEL SPEED (ipm)
0.025	0.030	15-17	30-50	15-20	15-20
.031	.030	15-17	40-60	15-20	18-22
.037	.035	15-17	65-85	15-20	35-40
.050	.035	17-19	80-100	15-20	35-40
.062	.035	17-19	90-110	20-25	30-35
.078	.035	18-20	110-130	20-25	25-30
.125	.035	19-21	140-160	20-25	20-25
.125	.045	20-23	180-200	20-25	27-32
.187	.035	19-21	140-160	20-25	14-19
.187	.045	20-23	180-200	20-25	18-22
.250	.035	19-21	140-160	20-25	10-15
.250	.045	20-23	180-200	20-25	12-18

GMAW ELECTRODES AND RELEVANT INFORMATION.

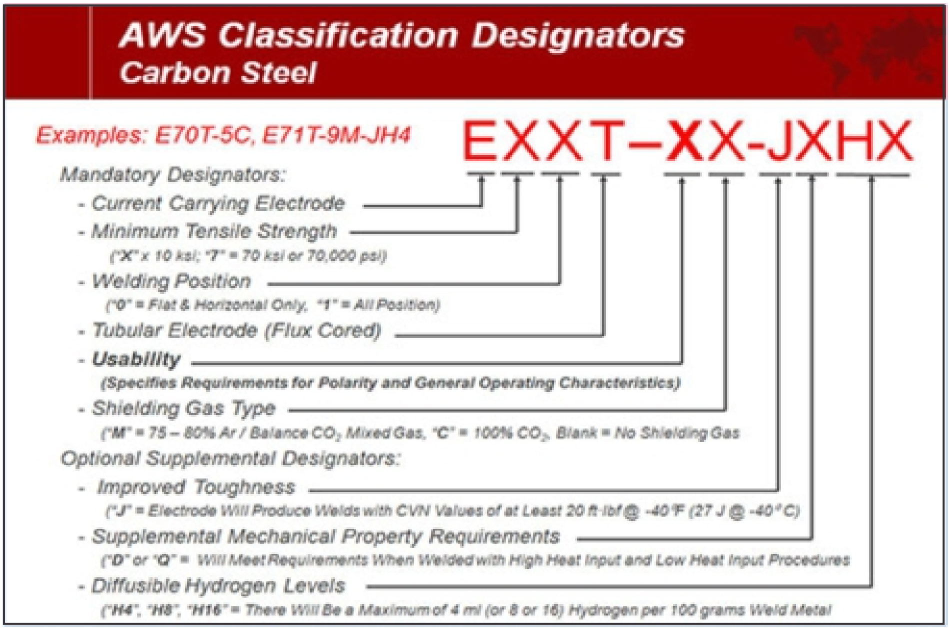
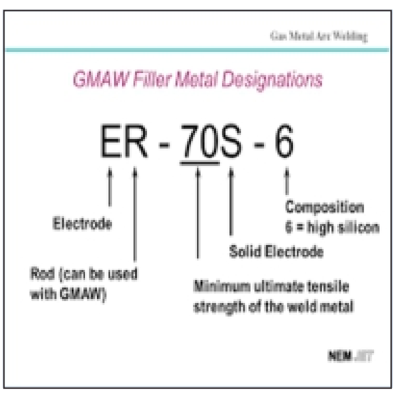
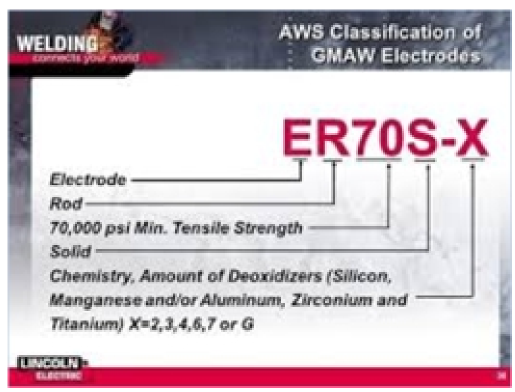
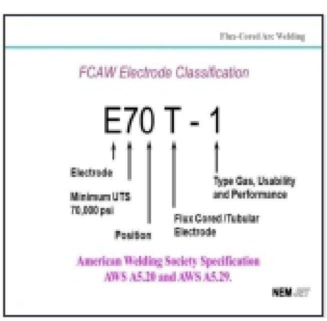


Fig. V : AWS Classification of GMAW Electrodes







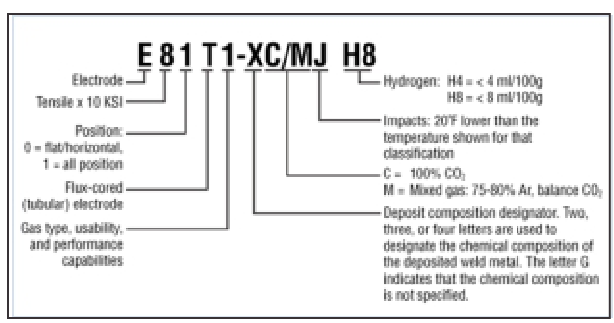


Table – XI : Deposition Efficiency of Welding Processes

Welding Process	Typical Deposition Efficiency Range (%)
FCAW-G (Gas-shielded)	80-88
FCAW-S (Self-shielded)	72-78
GMAW (MIG)	96-98
GTAW (TIG)	92-96
SAW	96-98*
SMAW (Stick)	50-55

*Values do not account for flux consumption, only wire.

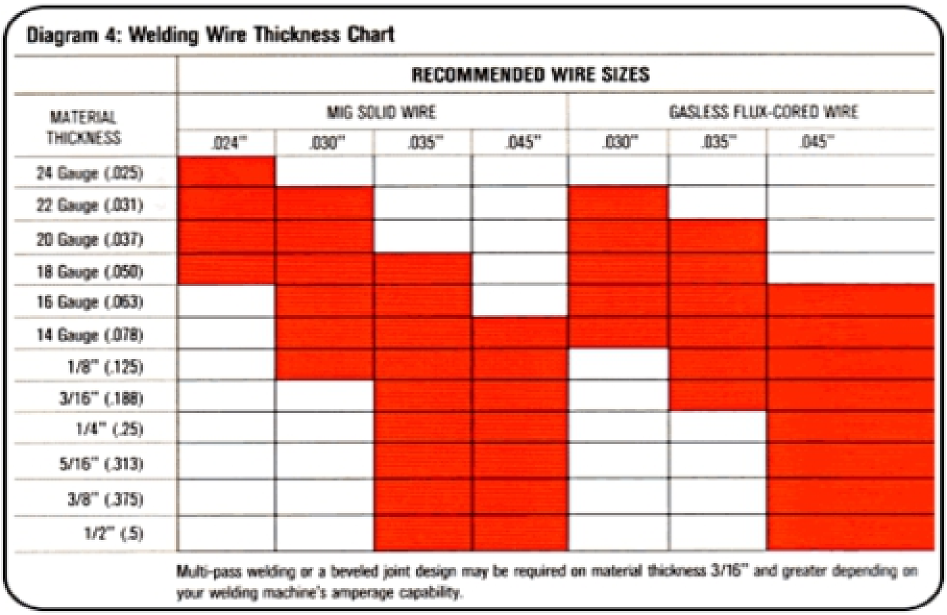


Fig. VII : Welding Wire Size For Material Thickness

Welding Wire Thickness Charts

Wire Size – Amperage Range – WFS Range Relationships

For Short Circuit Transfer on Steel

Wire Size	Amperage Range	Wire Feed Speed Range
.023"	30-90	100-400
.030"	40-145	90-340
.035"	50-180	80-380
.045"	75-250	70-270

Welding Wire/Method Recommendations

Wire Type	Considerations
Solid Carbon-Steel ER70S-6	May be used with CO2 or 75% Argon/25% CO2 (C-25), SteelMIX®, SteelMIX® 3 or SteelMIX® Extra
	CO2 gas provides deeper penetration
	75% Argon/25% CO2 has less spatter than CO2. SteelMIX(s) have less than either
	Indoor use with no wind
	For auto body, manufacturing, fabrication
	Welds thinner materials (22 gauge) than flux cored wires
Flux Cored/ Carbon-Steel E71T-GS	No shielding gas required
	Excellent for outdoor windy conditions
	For dirty, rusty, painted materials
	Hotter than solid wires, welds to 18 gauge materials and thicker
Solid Aluminum ER-4043 ER-5356	Must be used with Argon, AluMIX™, or other Argon/ Helium mixes
	Recommended to be used with spool guns for best results
	5356 is harder for stronger welds and easier feeding
Solid Stainless Steel ER308/308L	Use with StainMIX™ 3 or Helium/Argon/CO2 mixtures
	For 301, 302, 304, 305 and 308 stainless base metals

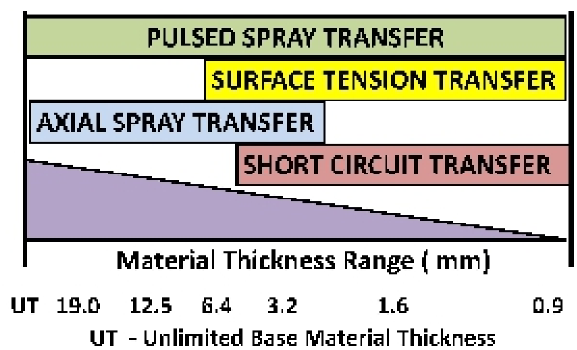
Welding Wire Thickness Charts

Material Thickness	MIG Solid Wire Size			Gasless Flux-Cored Wire Size		
	.023"	.030"	.035"	.030"	.035"	.045"
22 Gauge (.031)	■	■				
20 Gauge (.037)	■	■		■		
18 Gauge (.050)	■	■	■	■	■	
16 Gauge (.063)		■	■	■	■	■
14 Gauge (.078)		■	■	■	■	■
1/8" (.125)		■	■		■	■
3/16" (.188)			■		■	■
1/4" (.25)			■			■
Amperage	30-90	40-145	50-180	40-145	50-180	75-250
Wire Speed ipm	100-400	90-340	80-380	90-340	80-380	70-270

Metal Thickness - Amperage Required

Gauge Number	Fraction Of An Inch	Amperage	Amps/Inch
18	3/64" = .047	47	Formula
16	1/16" = .062	62	M X 1,000 = A
14	5/64" = .078	78	M = Material (.000")
12	1/10" = .100	100	A = Welding Amps
10	1/8" = .125	125	
8	5/32" = .156	156	
6	3/16" = .187	187	

GMAW - MODE OF METAL TRANSFER



GMAW Mode of Metal Transfer Selector

Fig. VIII : Wire Thickness Selection - Selection Of Electrodes

Table – XI : Transfer Parameters

Recess/ Extension	Amperage	Wire Stick-out	Process	Notes
1/4-in. Recess	> 200	1/2 - 3/4in.	Spray, high-current pulse	Metal-cored wire, spray transfer, argon-rich mixed gas
1/8-in. Recess	> 200	1/2 - 3/4in.	Spray, high-current pulse	Metal-cored wire, spray transfer, argon-rich mixed gas
Flush	< 200	1/4 - 1/2in.	Short-circuit, low-current pulse	Low argon concentrations or 100 percent CO_2
1/8-in. Extension	< 200	1/4 in.	Short-circuit, low-current pulse	Difficult-to-access joints

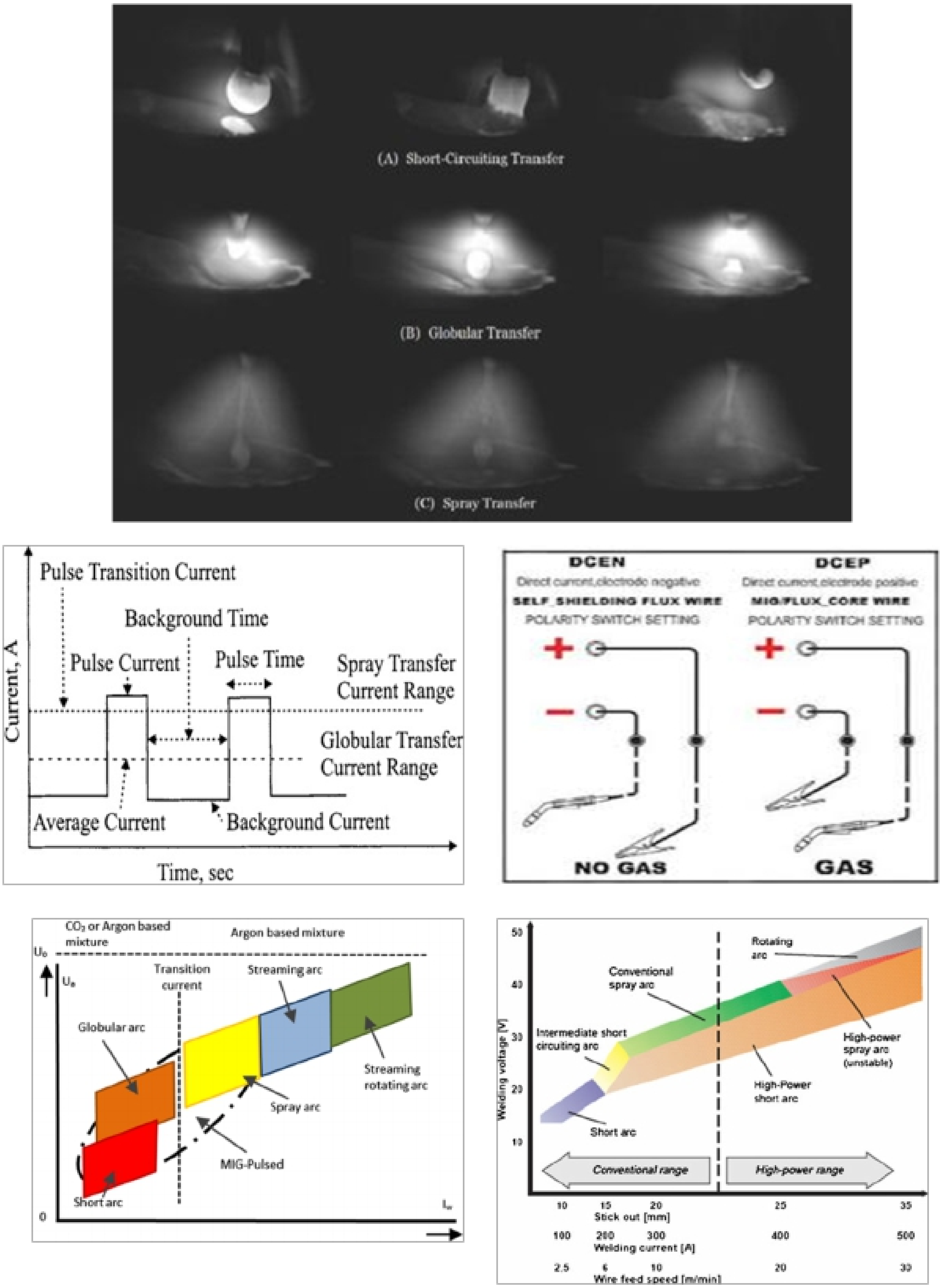
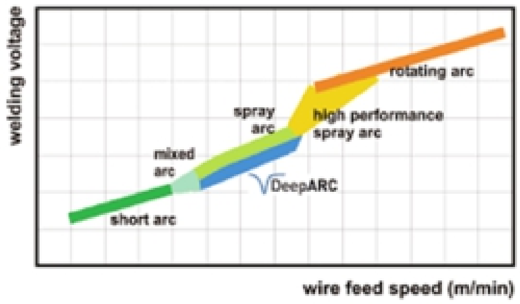
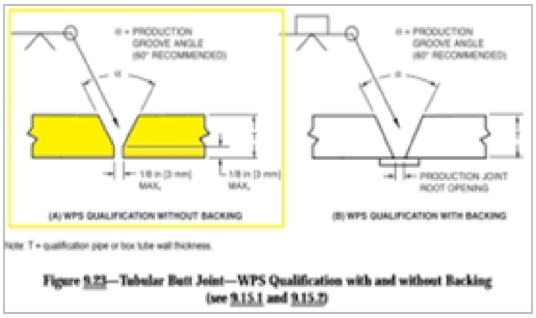
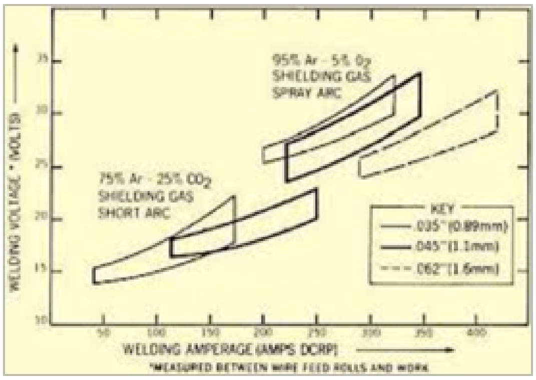


Fig. IX : GMAW – Metal Transfer







1 ampere for every .001 thickness

1/8" material = .125 = 125 Amperes

Wire Burn Off:

.023 - 3.5" wire/amp - 125 amps = 437 IPM

.030 - 2" wire/amp - 125 amps = 250 IPM

.035 - 1.6" wire/amp - 125 amps = 200 IPM

Fig. X : Metal Transfer Modes With Parameters

TABLE – X : A. METAL TRANSFER MODES/ DATA

TABLE – XI. GMAW Axial Spray Transfer data for Solid Composite Steels and Carbon Electrodes and Stainless Steel Solid Wire Electrodes GMAW Axial Spray Transition Currents for Solid Composite Steels and Carbon Electrodes and Stainless Steel Solid Wire Electrodes.

Metal Type	Diameter		Shielding Gas		Current
Carbon and Low Alloy	Inches	(mm)	Argon,	CO_2	(Amps)
Steels	0.030	((0.9)	90%	10%	155 - 165
	0.035	0.8)	90%	10%	215 - 225
	0.052	(1.3)	90%	10%	265 - 275
	0.062	(1.6)	90%	10%	280 - 290
	0.035	(0.9)	98%	2%	130 - 140
	0.045	(1.2)	98%	2%	205 - 215
	0.052	(1.3)	98%	2%	240 - 250
	0.062	(1.6)	98%	2% O_2	260 - 275
Carbon and Low Alloy	0.040	(1.0)	90%	10%	140 - 150
Composite Steel	0.045	(1.2)	90%	10%	160 - 170
	0.052	(1.3)	90%	10%	170 - 180
	0 .062	(1.6)	90%	10%	220 - 230
Stainless	0.030	(0.8)	98%	2% O_2	120 - 130
Steels	0. 035	(0.9)	98%	2% O_2	140 - 150
	0.045	1.2)	98%	2% O_2	185 - 195
	0.062	(1.6)	98%	2% O_2	250 - 200
	0.030	(0.8)	98%	2%	130 - 140
	0.035	(0.9)	98%	2%	200 - 210
	0.045	(1.2)	98%	2%	145 - 155
	.062	(1.6)	98%	2%	255 - 265

Table – X-B : Metal Transfer Modes/ Data

Process	Diameter of wire (mm)	Voltage	Ampere	Shielding Gas
SGMAW pray Transfer	0.9	28 - 32	165 - 200	98% Argon + 2 % Oxygen OR 75% Argon + 25% CO_2
	1.14	30 - 34	180 - 220	
	1.6	30 - 34	230 - 260	
GMAW Short Circuit Transfer	0.9	22 - 25	100 - 140	100% CO_2 75% Argon + 25% CO_2
	1.14	23 - 26	120 - 150	

Gas	Wire Diameter	Amps	Volts	Wire Feed Speed m/min	Transfer Mode
$Ar + O_2 + CO_2$	1.0mm	152	22.5	7.8	Spray
	1.0mm	48	16.1	2.4	Pulsed
	1.0mm	83	16	3.6	Dip
$Ar + He + CO_2$	1.0mm	178	27	8.7	Spray
	1.0mm	50	17.9	2.9	Pulsed
	1.0mm	47	16.2	2.1	Dip
$Ar + O_2$	1.0mm	147	22	6.9	Spray
	1.0mm	49	15.9	2.5	Pulsed
	1.0mm	73	16.7	3.2	Dip

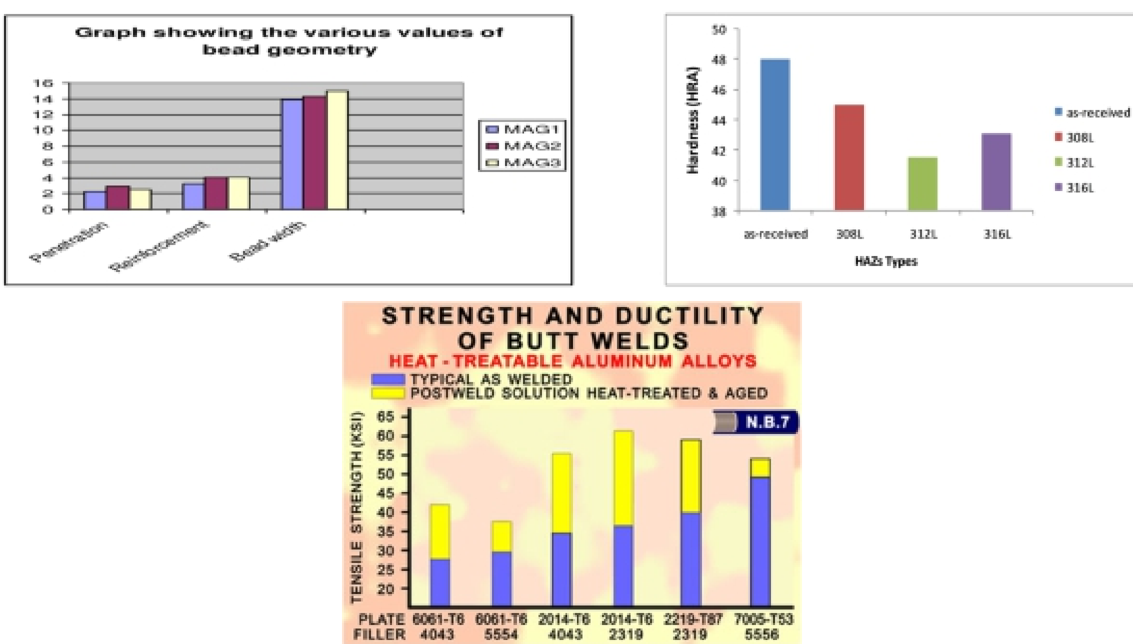
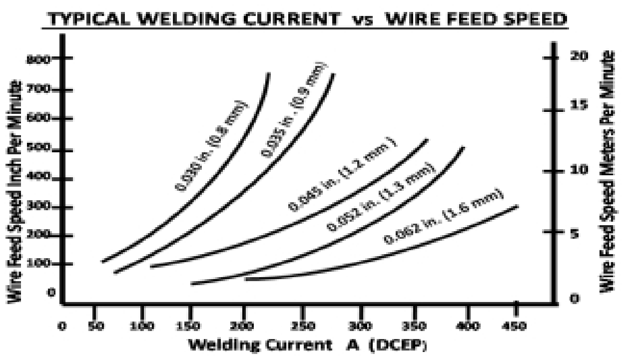


Fig. X : Welded Bead Characteristics

MECHANICAL PROPERTIES(1) – As Required per AWS A5.20/A5.20M: 2005					
	Yield Strength(2) MPa (ksi)	Tensile Strength MPa (ksi)	Elongation %	Charpy V-Notch J (ft•lbf) @ -18°C (0°F)	Charpy V-Notch J (ft•lbf) @ -29°C (-20°F)
Requirements(4) AWS E71T-1C H8, E71T-1M H8 AWS E71T-9C H8, E71T-9M H8	400 (58) min.	480 - 655 (70 - 95)	22 min.	27 (20) min. Not Specified	Not Specified 27 (20) min.
Typical Performance(3) As-Welded with: 100% CO_2 75% Ar/25% CO_2	510 - 550 (73 - 79) 570 - 610 (82 - 88)	570 - 600 (82 - 87) 620 - 660 (89 - 95)	26 - 28 24 - 26	38 - 95 (28 - 70) 62 - 111 (46 - 82)	27 - 65 (20 - 48) 39 - 85 (29 - 63)

DEPOSIT COMPOSITION(1) – As Required per AWS A5.20/A5.20M: 2005						
	%C	%Mn	%Si	%S	%P	Diffusible Hydrogen (mL/100g weld deposit)
Requirements(4) AWS E71T-1C H8, E71T-1M H8 AWS E71T-9C H8, E71T-9M H8	0.12 max.	1.75 max.	0.90 max.	0.03 max.	0.03 max.	8 max.
Typical Performance(3) As-Welded with: 100% CO_2 75% Ar/25% CO_2	0.03 - 0.04 0.03 - 0.04	1.28 - 1.41 1.45 - 1.60	0.42 - 0.49 0.54 - 0.62	0.01 0.01	0.01 - 0.02 0.01 - 0.02	3 - 8 4 - 8

CURRENT DENSITY



Deposition Rate

WELDING PROCESS	TYPICAL DEPOSITION EFFICIENCY RANGE (%)
FCAW - G (GAS SHIELDED)	80 - 88
GMAW (MIG)	96 - 98

Table XIII : Welding Parameters

Set (Transfer mode)	Specimen #	Av. Voltage (V)	Av. Current (A)	WFS (ipm)	T. Speed (ipm)	C.W. Mass (%)	Nom. Heat Input (kJ/mm)
1 (Globular)	1	25.06	220.30	250	25	0	0.55
	2	25.07	234.40	250	25	60	0.55
	3	25.19	225.90	250	50	0	0.27
	4	25.16	224.60	250	50	60	0.26
2 (Short-Circuit)	1	17.15	95.56	100	25	0	0.16
	2	17.14	115.30	100	25	42	0.19
	3	17.09	98.56	100	50	0	0.08
	4	17.04	105.25	100	50	42	0.08

Table XIV : Electrode Diameter And Welding Parameters

WELDING DATA:

The information listed below was determined by welding performed with DCEP welding current with 75% AR-25% CO_2.

RECOMMENDED OPERATING PARAMETERS:

Diameter Electric Stickout Position	Arc Voltage (Volts)	Current DCEP (+) Amps	Approx. Wire Feed Speed in/min	Deposition Rate (lbs/hr)
.035" (0.9 mm) 1/2" (12.7 mm) Flat, Horizontal & Vertical Up	23 **24-29** 31	80 **110-130** 150	180 **280-375** 550	2.2 **3.3-4.5** 6.6
.045" (1.2 mm) 5/8" - 3/4" (16 mm - 19 mm) Flat, Horizontal & Vertical Up	24 **25-29** 33	140 **160-200** 300	210 **275-380** 680	5.0 **6.0-8.0** 15.0
1/16 (1.6 mm) 3/4" - 1" (19 mm - 25.4 mm) Flat, Horizontal & Vertical Up	28 **29-33** 35	200 **240-280** 350	155 **230-290** 420	6.5 **8.5-11.0** 16.0

*When using CO_2 shielding gas, add 1-2 volts.

Table. XV : TYPICAL OPERATING PROCEDURE

Typical Operating Procedures

Diameter, Polarity CTWD[1] Transfer Mode Shielding Gas	Wire Feed Speed in/min	Arc Voltage (volts)	Approx. Current (amps)	Melt-Off Rate lbs/hr
.035", DC+				
3/8-1/2"	100	18	80	1.6
Short Circuit Transfer	150	19	120	2.4
100% CO2	250	22	175	4.0
1/2-3/4"	375	23	195	6.0
Spray Transfer	500	29	230	8.0
90% Ar/10% CO2	600	30	275	9.6
.045", DC+				
3/8-1/2"	125	19	145	3.4
Short Circuit Transfer	150	20	165	4.0
100% CO2	200	21	200	5.4
1/2-3/4"	350	27	285	9.2
Spray Transfer	475	30	335	12.5
90% Ar/10% CO2	500	30	340	13.2
.052", DC+				
3/4-1"	300	30	300	10.6
Spray Transfer	320	30	320	11.5
90% Ar/10% CO2	485	32	430	17.1
1/16", DC+				
3/4-1"	210	25	325	10.7
Spray Transfer	235	27	350	12.0
90% Ar/10% CO2	290	28	430	14.8

Note: Procedures in the shaded areas are procedures for short circuiting mode using 100% CO2. When using 75% Argon, 25% CO2 for short circuit transfer, reduce voltage by 1 to 2 volts

1 CTWD (Contact Tip to Work Distance). Subtract 1/16" for MIG short arc, 3/16" for axial spray to calculate Electrical Stickout.

Short Circuit Transfer Welding Parameters

Material Thickness[1]	Electrode Diameter (inches)	Welding Current (Amps-DC)	Arc Voltage (Electrode Positive)	Wire Feed Speed (IPM)	Travel Speed (IPM)	Shielding Gas Flow (CFH[2])
24 ga.	.030"	35-50	15-17	85-100	12-20	15-20
22 ga.	.030"	40-60	15-17	90-130	18-22	15-20
20 ga.	.025"	55-85	15-17	70-120	35-40	15-20
18 ga.	.035"	70-100	16-19	100-160	35-40	15-20
1/16"	.035"	80-110	17-20	120-180	30-35	20-25
5/64"	.035"	100-130	18-20	160-220	25-30	20-25
1/8"	.035"	120-160	19-22	210-290	20-25	20-25
1/8"	.045"	180-200	20-24	210-240	27-32	20-25
3/16"	.035"	140-160	19-22	210-290	14-19	20-25
3/16"	.045"	180-205	20-24	210-245	18-22	20-25
1/4"	.035"	140-160	19-22	240-290	11-15	20-25
1/4"	.045"	180-225	20-24	210-290	12-18	20-25

Note: Single-pass flat and horizontal fillet positions. Reduce current 10 to 15% for vertical and overhead welding.

1 For fillet and groove welds - for fillet welds, size equals metal thickness; for square groove welds, the root opening should equal 1/2 the metal thickness.

2 Shielding gas is CO_2 or 75% Ar / 25% CO_2

Table XVI : Typical Operating Procedure

(Manual travel, single pass, flat fillet welds)

MATERIAL THICKNESS (inches)	ELECTRODE SIZE	WELDING DCRO (arc volts)	CONDITIONS (amperes)	GAS FLOW (cfh)	TRAVEL SPEED (ipm)
0.025	0.030	15-17	30-50	15-20	15-20
.031	.030	15-17	40-60	15-20	18-22
.037	.035	15-17	65-85	15-20	35-40
.050	.035	17-19	80-100	15-20	35-40
.062	.035	17-19	90-110	20-25	30-35
.078	.035	18-20	110-130	20-25	25-30
.125	.035	19-21	140-160	20-25	20-25
.125	.045	20-23	180-200	20-25	27-32
.187	.035	19-21	140-160	20-25	14-19
.187	.045	20-23	180-200	20-25	18-22
.250	.035	19-21	140-160	20-25	10-15
.250	.045	20-23	180-200	20-25	12-18

TABLE XVI : GMAW - OPERATIONAL PARAMETERS
(Data from : www.lincolnelectric.com)

CTWD(1) : 1/2" (13mm)
Gas: 100% CO2
Gas flow: 25 to 35 cfh (12 to 17 L/min.)

Plate Thickness - (mm)	24 ga (0.6)	18 ga (1)	14 ga (2)	10 ga (4)	3/16" (5)	1/4" (6)
Electrode Dia. - in. (mm)	0.025 0.030 (0.6) (0.8)	0.030 0.035 (0.8) (0.9)	0.030 0.035 (0.8) (0.9)	0.030 0.035 0.045 (0.8) (0.9) (1.1)	0.045 (1.1)	0.045 (1.1)
WFS - in./min M/min.)	100 75 (2.5) (1.9)	150 125 (3.8) (3.2)	225 175 (5.7) (4.4)	300 250 125 (7.6) (6.4) (3.2)	150 (3.8)	200 (5.0)
Amps (Approximate)	35	35 70 100	100 130	130 175 145	165	200
Travel Speed - in./min (M/min.)	10 (0.25)	10 15 19 (0.25) (0.38) (0.48)	20 20 (0.50) (0.50)	20 20 20 (0.50) (0.50) (0.50)	17 (0.43)	17 (0.43)
Voltage (2) (DC+)	17 17	18 18	20 20	22 22	19 20	21