MMA Manual Metal Arc Welding

Features

The manual metal arc process provides a universal maintenance tool which is both flexible and cost effective.

Most metals can be joined or overlaid by a single process for a wide range of applications. A wide range of consumable electrodes is available, each electrode having a gas-producing coating which obviates the need for additional gas supplies.

In addition to joining of materials, the process is also used for hardfacing, cutting and gouging. Features are summarised as follows:

- Cost effective process.
- No gas supplies required.
- Flexible application.
- Wide range of consumables.

Equipment (high current range) may also be used for other processes (e.g. cutting, hardfacing and gouging).

Typical Applications

The flexibility of the process, the range of output current and the wide range of consumables available makes the list of process applications a long one. The following is a list of typical applications within the four basic current ranges.

- 50 to 150 Amps – Domestic/DIY, light duty batch welding.
- 150 to 250 Amps – Repair and maintenance, light engineering.
- 250 to 350 Amps – Light and medium production work, batch shop work.
- 350 to 650 Amps – Heavy engineering and shipbuilding.

For a more detailed list of applications, by electrode type, see the latest issue of the Murex Arc and Gas Welding Consumables catalogue.

Equipment

There are three basic types of power source for manual metal arc welding:

- AC transformer
- AC/DC transformer rectifier
- Motor generator

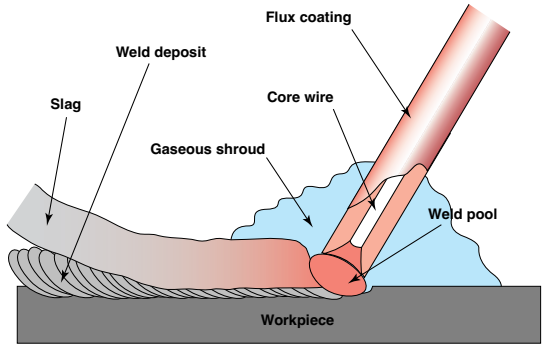
These power sources are usually designed to cover a specific welding current range e.g. 50-150 Amps, 150- 250 Amps, 250-350 Amps and 350-650 Amps with open circuit voltages of between 40 and 80 volts.

A 'constant current' characteristic power source is preferred because of the difficulty in maintaining a constant arc length. With a constant current characteristic, large fluctuations in arc voltage (arc length) produce minimal changes in current.

Voltage reduction device (VRD)

Whilst the arc is established the welding voltage is relatively safe, however, the value of open circuit voltage (arc extinguished) may be sufficient to be the cause of accidents due to electric shock.

When fitted to the output terminals of a power source, a voltage reduction device automatically 'senses' the rise in open circuit voltage when the arc is extinguished and shuts down the output voltage from the power source to a safe level.



WARNING: Adequate safety precautions must be taken to offset the effect of heat, glare and fumes

Process Description

Manual Metal Arc welding is a process in which an electric arc is struck between two metals (the workpiece and the consumable electrode). The heat generated by the arc is sufficient to melt both metals and the metal from the consumable electrode is deposited on the workpiece by gravity and/or 'arc force'.

To prevent ingress of oxygen and nitrogen from the atmosphere into the weld pool, the arc is shielded by the melted down flux coating of the electrode in two forms:

(1) GAS - bulk of coating material produces a gas which shrouds the weld pool.

(2) SLAG - coating material converts to slag which covers the solidifying metal.

When the arc is struck the voltage across the arc (electrode to workplace) falls to a value dependent upon arc length. For normal arc length this voltage is called the 'arc voltage'. The voltage before arc striking occurs is called the 'open circuit voltage (OCV)'. In general, the correct arc length is one which approximately equal to the electrode diameter.

Electrode data may call for either dc negative, positive, or ac polarity outputs from the power source to suit a particular electrode characteristic.

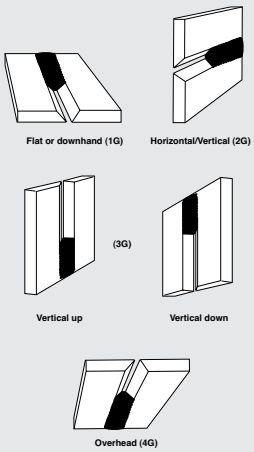
Accessories

To provide a safe and comfortable working environment whilst MMA welding and to make the welding jobs easier, a wide range of accessories are available:

- Helmets & handshields
- Filter & cover lenses
- Screens & curtains
- Metal markers
- Cable connectors
- Cables
- Visors
- Anti-spatter sprays
- Respiratory protection
- Clothing
- Wire brushes
- N.D.T Aerosols
- Work return clamps
- Goggles
- Safety spectacles
- Torches

Basic Welding Positions

There are four basic welding positions, flat (or downhand), horizontal/ vertical, vertical up (or down) and overhead. These positions are illustrated below. For the full range of ASME/ISO welding positions, see below.



Electrode Classification

Electrodes are of differing types according to the material to be welded and the application. The American Welding Society (AWS) and the British Standards Institute (BSI) are among the organisations classifying electrodes according to coating type and performance. A guide to these classifications is given in the panels below.

AWS Classification A5.1

Mild Steel Electrodes

The method of classifying of electrodes is based on the use of a four-digit number, preceded by the letter 'E' for 'Electrode'.

The first two digits designate the minimum tensile strength of the weld metal (in 1,000 psi) in the as-welded condition,

The third digit indicates the position in which the electrode is capable of making satisfactory welds.

The fourth digit indicates the current to be used, and the type of flux coating.

For example, the classification of E6012 electrodes is derived as follows:

E6012 = Metal arc welding electrode.
E6012 = Weld metal UTS 60,000 psi min.
E6012 = Usable in all positions.
E6012 = Rutile type coating; AC or DC negative.

The detail of the classification is shown below.

First and second digits

E60xx As-welded deposits, UTS 60,000 psi min. for E6010, E6011, E6012, E6013, E6020, E6027.

E70xx As-welded deposit, UTS 70,000 psi min. for E7014, 7015, 7016, 7018 E7024 and E7028.

Third and fourth digits

The third and fourth digits indicate positional usability and flux coating types.

Exx10 High cellulose coating, bonded with sodium silicate. Deeply penetrating, forceful, spray-type arc. Thin, friable slag. All-positional DC electrode positive only.

Exx11 Very similar to Exx10, but bonded with potassium silicate to permit use on AC or DC positive.

Exx12 High rutile coating, bonded with sodium silicate. Quiet arc, medium penetration, all-positional. AC or DC negative.

Exx13 Coating similar to Exx12, but with addition of easily ionised material and bonded with potassium silicate to give steady arc on low voltage supply. Slag is fluid and easily removed. All-positional electrode. AC or DC negative.

Exx14 Coating similar to Exx12 and Exx13 types with addition of medium quantity of iron powder. All-positional AC or DC.

Exx15 Lime-fluoride coating ('basic, low-hydrogen') type, bonded with sodium silicate. All-positional. For welding high tensile steels. DC positive only.

Exx16 Similar coating to Exx15, but bonded with potassium silicate. AC or DC positive.

Exx18 Coating similar to Exx15 and Exx16 but with addition of iron powder. All-positional. AC or DC.

Exx20 High iron oxide coating bonded with sodium silicate. For welding in flat or HV positions. Good X-ray quality. AC or DC.

Exx24 Heavily coated electrode having flux ingredients similar to Exx12 and Exx13 with addition of high percentage of iron powder for fast deposition rates. Flat and horizontal positions only. AC or DC.

Exx27 Very heavily coated electrode having flux ingredients similar to Exx20 type, with addition of high percentage of iron powder. Flat or horizontal positions. High X-ray quality. AC or DC.

Exx28 Similar to Exx18 but heavier coating, and suitable for use in flat and HV positions only. AC or DC.

BS EN ISO 2560-A

This specification is divided into two parts: Part A, classification based on yield strength and the average imput energy of 47J. Part B, classification based on tensile strength and the average impact energy of 27J. Use of this classification system is best illustrated by the example below.

Example Part A	Additional code	
Hi-Trex 8016-G	E 50 6 Mn1Ni B	12 H5

Consumable type - E

E is for covered electrode for manual metal arc welding. No other consumable type is covered by this specification.

Strength - 50

	YS	TS	El
	N/mm²		%
E 35 x x x	355	440 - 570	22
E 38 x x x	380	470 - 600	20
E 42 x x x	420	500 - 640	20
E 46 x x x	460	530 - 680	20
E 50 x x x	500	560 - 720	18

For yield strength the lower yield (R_{eL}) shall be used when yielding occurs, otherwise the 0.2% proof stress ($R_{p0.2}$) shall be used.

Toughness - 6

Temperatures for minimum average impact energy of 47J

E xx Z x x	No requirement
E xx A x x	+ 20
E xx 0 x x	0
E xx 2 x x	-20
E xx 3 x x	-30
E xx 4 x x	-40
E xx 5 x x	-50
E xx 6 x x	-60

Composition - Mn1Ni

	All-weld metal composition		
	Mn	Mo	Ni
E xx x - x	2.0	-	-
E xx x Mo x	1.4	0.3 - 0.6	-
E xx x MnMo x	>1.4 - 2.0	0.3 - 0.6	-
E xx x 1Ni x	1.4	-	0.6 - 1.2
E xx x 2Ni x	1.4	-	1.8 - 2.6
E xx x 3Ni x	1.4	-	>2.6 - 3.8
E xx x Mn1Ni x	>1.4 - 2.0	-	0.6 - 1.2
E xx x 1NiMo x	1.4	0.3 - 0.6	0.6 - 1.2

Single values in table are maximums.

Covering - B

E xx x x A	acid covering
E xx x x C	cellulosic covering
E xx x x R	rutile covering
E xx x x RR	rutile thick covering
E xx x x RC	ritile-cellulosic covering
E xx x x RA	rutile-acid covering
E xx x x RB	rutile-basic covering
E xx x x B	basic covering

Efficiency and Current - 12

	Weld metal recovery (%)	Type of current
1	< 105	a.c. + d.c.
2	< 105	d.c.
3	> 105 < 125	a.c. + d.c.
4	> 105 < 125	d.c.
5	> 125 < 160	a.c. + d.c.
6	> 125 < 160	d.c.
7	> 160	a.c. + d.c.
8	> 160	d.c.

Welding Position - 12

1	PA, PB, PC, PD, PE, PF, PG
2	PA, PB, PC, PD, PE, PF
3	PA, PB
4	PA
5	PA, PB, PG

Hydrogen content - H5

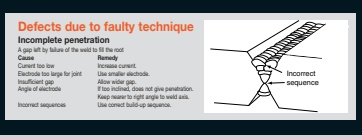
	Hydrogen content ml/100g all-weld metal
H5	5 max.
H10	10 max.
H15	15 max.

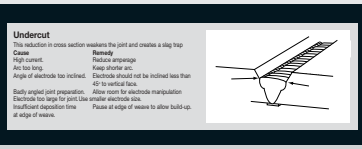
ASME/BS EN ISO Welding Positions

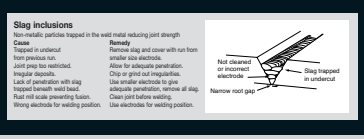
The easiest position for welding is the flat or downhand position. Any deviation from this position, other than small variations in slope, makes successful welding much more difficult. This is because gravity does not assist in positioning of the weld metal.

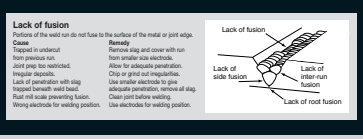
Positional welding (other than flat) often relies on an arc force and surface tension effect, therefore the welding position may affect the mechanical properties of the weld and the likelihood of defects.

For simplicity, the various welding positions are coded as shown below, eg '3G/PF' vertical up butt weld.









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