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

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"AN APPROACH TO BEST WELDING PRACTICE. Part – XXI." 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 IVa is particularly focused on the Generation and Computer based Storage of Welding Data on FCAW Process 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 data storage of welding processes must be done.

The Importance of Record Keeping

Record keeping critical in case of Fabrication and Manufacturing concerns employing welding as the main manufacturing process, as because welding is a **"Special Process"** and the Product acceptance is dependent upon follow up of a number of Procedures, Codes and Standards. Documentation of all these proceedings are to be meticulously prepared and maintained – normally by the **"Welding Engineer"** or **"Welding Co-ordinator"**. Again, apart from documentation so many data related to the Power Source, Electrodes, Gases used, Maintenance schedules etc. are to be coordinated with variety of data converging for a product to be manufactured and to be accepted by the customer. Normally, most of these are paperwork and the tendency is either to destroy the past records of papers or to dump them somewhere beyond restoration. Even the large volume of information kept in mind of the Welding Engineer or the Welding Coordinator in course of work are irretrievable to any new incumbent or others.

It is an accepted fact now that data collection, storage and retrieval can not be done effectively with human individuals or even by groups and possibilities of distortion of retrievable data cannot be ruled out.

I. What 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

II. 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.

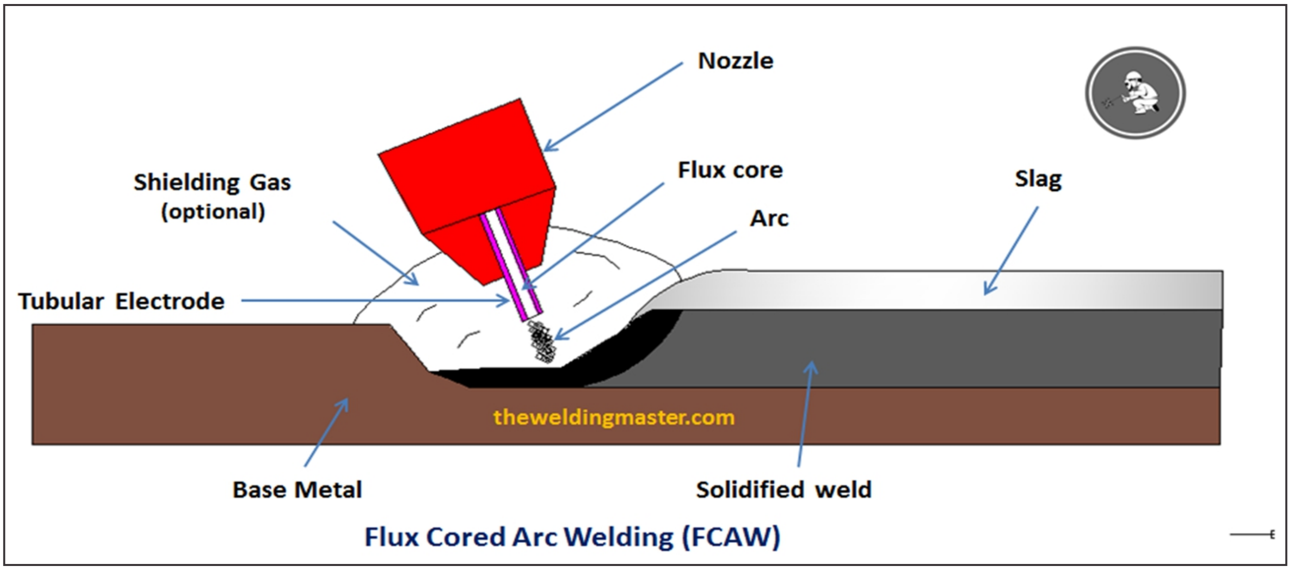
An integrated system will include:

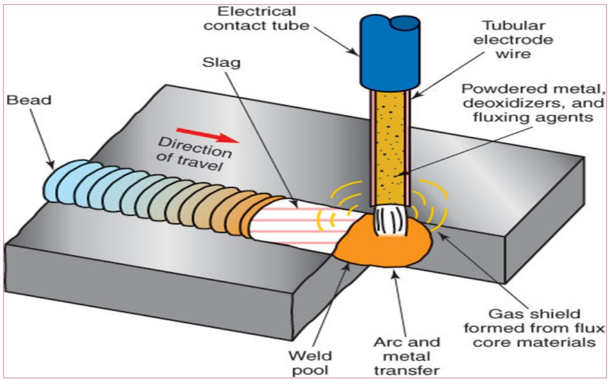
- Filler and base metals and their chemical and mechanical properties;
- Histories of welder qualification and the quality of welds by each welder;
- Welding-procedure information, including WPSs, PQRs, and pre- and post weld heat-treatment information;
- Design information, including joint design graphics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

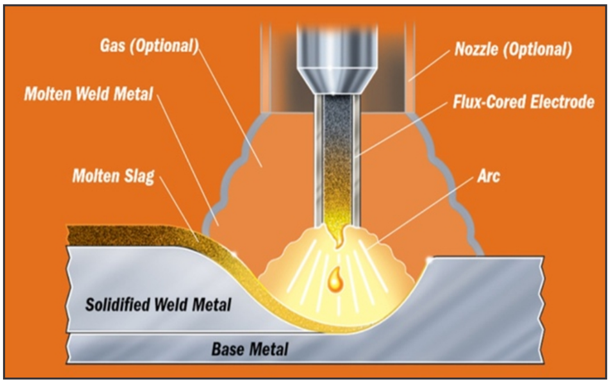
The softwares art all designed to operate in the computing environment of the desktop computer, turning the computer into a welding engineering work station.

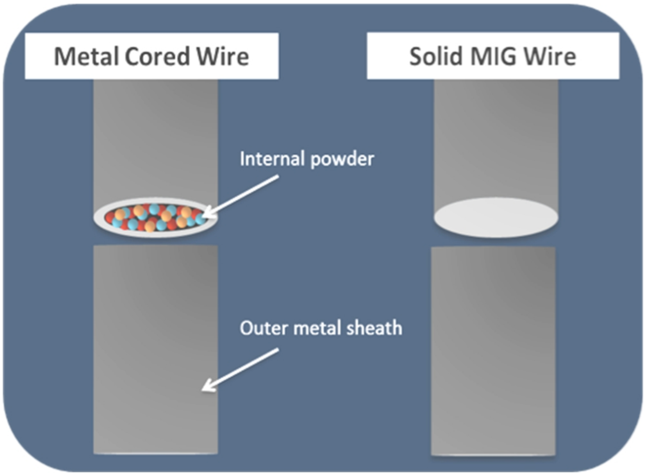
Flux cored arc welding, (FCAW), is evolved from the gas metal arc welding, or GMAW process to improve arc action, increased metal transfer, weld metal properties, and weld appearance. The heat is provided by an arc between a continuously fed tubular electrode wire and the workpiece. The major difference is that FCAW utilizes an electrode very different from the solid electrode used in GMAW. In fact, it is closer to the electrodes used in shielded metal arc welding, or SMAW or stick welding, except the flux is on the inside of a flexible electrode instead of on the outside of a very stiff electrode.

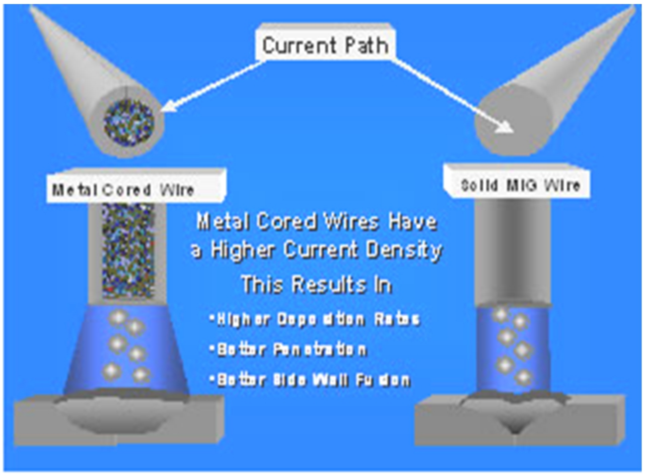
FLUX CORED ARC WELDING (FCAW)











Metal cored gas-shielded wire combines the high deposition rates of a flux cored wire with the high efficiencies of a solid wire. Productivity improves with the increased deposition rates and higher travel speeds, combine this with the minimal spatter and lack of clean up required due to the slag free welds and the labour costs will reduce. The up-front cost of metal cored wires is higher but filler metals only make up at most 10% of a weld's cost and gas around 3%. In almost all applications, labour accounts for 75% of the total cost so any significant productivity increase from switching to metal-cored wire will out-weigh the increase in the filler metal cost.

Concentrating the welding current through the outside tube of MCW results in a broader, bowl-shaped arc with finer droplets. This means MCWs fill imperfections and bridge gaps better, giving a quality weld with high structural integrity.

In addition, a quality metal-cored wire like KOB MX-A70C6LF, or NSSW's SM-3A, runs as much cleaner and smoother than solid wire, so not only extremely low spatter but less wear and tear on tips, liners, drive rollers, etc results, leading to savings in other consumable costs as well.

Welders usually prefer working with MCW as not only can they weld faster and smoother and easily produce great welds, their working environment is safer and healthier because of the much lower levels of fume.

The essential process, equipment and consumable data requirement are on :

- welding power source,
- remote controller,
- wire feeder,
- welding torch,
- welding wire, filler rod

Equipment for Welding

The equipment used for FCAW is very similar to that used for GMAW. The basic arc welding equipment consists of a power source, controls, wire feeder, welding gun, and welding cables. A major difference between the gas-shielded electrodes and self - shielded electrodes is that the gas shielded wires also require a gas shielding system. This may also have an effect on the type of welding gun used. Fume extractors are often used with this process. For machine and automatic welding, several items, such as seam followers and motion devices, are added to the basic equipment.

Power Source

The FCAW welding process needs a suitable and constant voltage power source (DC). FCAW equipment is generally more

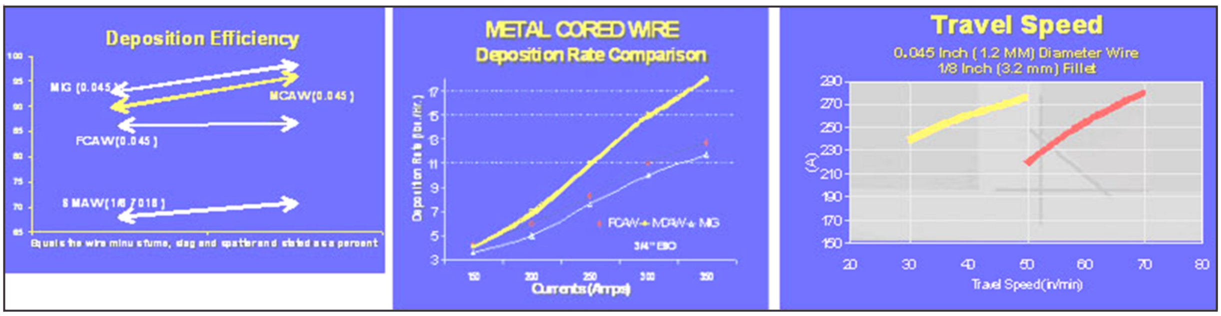


Fig. : Power Source

Water cooled Gun

Air cooled Gun

robust than GMAW plant and requires some skill to set up properly. Typical uses for the FCAW process include: heavy fabrication general engineering. FCAW has a better deposition rate and fusion than GMAW.

Types of Current

FCAW Process uses direct current, which can be connected in one of two ways: electrode positive (reverse polarity) or electrode negative (straight polarity). Flux-cored electrode wires are designed to operate on either DCEP or DCEN.

Shielding Gas

The choice of the proper shielding gas for a specific application is based on:

1. Type of metal to be welded
2. Arc characteristics and metal transfer
3. Availability
4. Cost of the gas
5. Mechanical property requirements
6. Penetration and weld bead shape.

Carbon Dioxide

The carbon dioxide shielding gas during welding breaks down into components as carbon and oxygen. Because carbon dioxide is an oxidizing gas, deoxidizing elements are added to the core of the electrode wire to remove oxygen. The oxides formed by the deoxidizing elements float to the surface of the weld and become part of the slag covering. Some of the carbon dioxide gas will break down to carbon and oxygen.

If the carbon content of the weld pool is below about .05%, carbon dioxide shielding will tend to increase the carbon content of the weld metal. Carbon reducing the corrosion resistance of some stainless steels, is a problem for critical corrosion applications.

Extra carbon can also reduce the toughness and ductility of some low-alloy steels. If the carbon content in the weld metal is greater than about 0 .10%, carbon dioxide shielding will tend to reduce the carbon content. This loss of carbon can be attributed to the formation of carbon monoxide, which can be trapped in the weld as porosity. Deoxidizing elements added in the flux core, reduces the effects of carbon monoxide formation.

Argon-Carbon Dioxide Mixtures

Argon and carbon dioxide are sometimes mixed for use with FCAW. A high percentage of argon gas in the mixture tends to promote a higher deposition efficiency due to creating less spatter. This mixture also creates less oxidation and lower fumes. The most commonly used argon-carbon dioxide mixture contains 75% argon and 25% carbon dioxide. This gas mixture produces a fine globular metal transfer that approaches a spray. It also reduces the amount of oxidation that occurs, compared to pure carbon dioxide. The weld deposited in an argon-carbon dioxide shield generally has higher tensile and yield strengths.

Argon-oxygen Mixture

Argon-oxygen mixtures containing 1 or 2% oxygen are used for a number of applications. Argon-oxygen mixtures tend to promote a spray transfer that reduces the amount of spatter. A major application of these mixtures is in welding stainless steels where carbon dioxide can cause corrosion problems.

Electrode Specification

An example of a carbon-steel electrode classification is E70T-4 where:

1. The "E" indicates an electrode.
2. The second digit indicates the minimum tensile strength in units of 70,000 psi (69 Mpa).
3. The third digit indicates the welding position. A "0" indicates flat and horizontal positions only, and a "1"

indicates all positions.

4. The "T" stands for a tubular (flux-cored) wire classification.
5. The suffix "4" gives the performance and usability capabilities When a "G" classification is used, no specific performance requirements are indicated. This classification is intended for electrodes not covered by another classification. The chemical composition requirements of the deposited weld metal for carbon steel.

Fig. : FCWA Electrodes

MECHANICAL PROPERTIES AND DEPOSIT COMPOSITION

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	400 (58) min.	480 - 655 (70 - 95)	22 min.	27 (20) min.	Not Specified
AWS E71T-9C H8, E71T-9M H8				Not Specified	27 (20) min.
Typical Performance(3) As-Welded with: 100% CO_2	510 - 550 (73 - 79)	570 - 600 (82 - 87)	26 - 28	38 - 95 (28 - 70)	27 - 65 (20 - 48)
75% Ar/25% CO_2	570 - 610 (82 - 88)	620 - 660 (89 - 95)	24 - 26	62 - 111 (46 - 82)	39 - 85 (29 - 63)

DEPOSIT COMPOSITION(1) – As Required per AWS A5.20/A5.20M: 2005

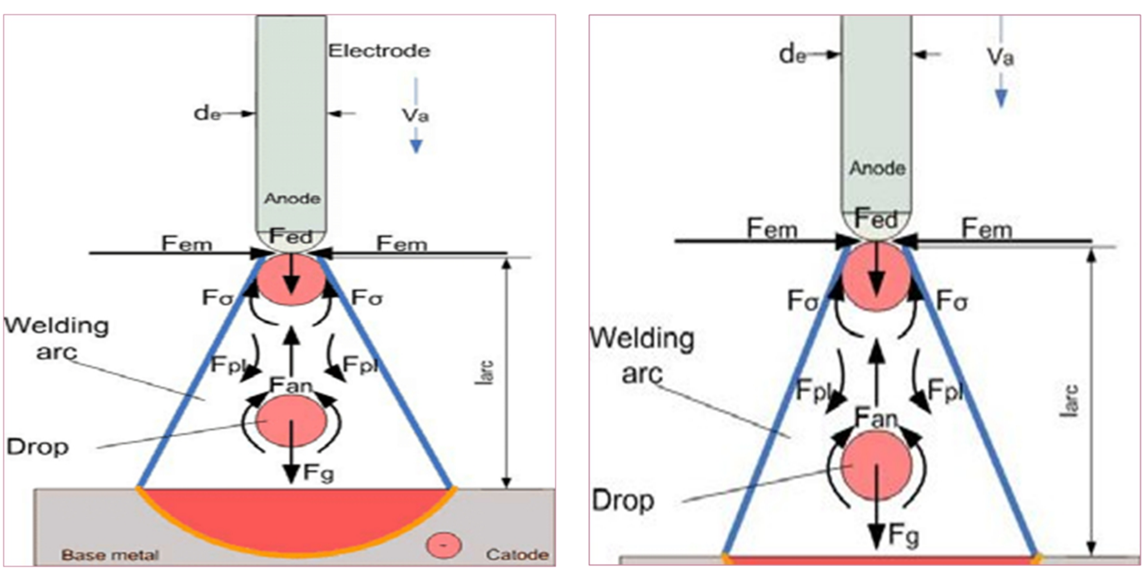
	%C	%Mn	%Si	%S	%P	Diffusible Hydrogen (mL/100g weld deposit)
Requirements(4) AWS E71T-1C H8, E71T-1M H8 AWS E71T-9C H8, E71T-9M H8	0.12 max.	1.75 max.	0.90 max.	0.03 max.	0.03 max.	8 max.
Typical Performance(3) As-Welded with: 100% CO_2	0.03 - 0.04	1.28 - 1.41	0.42 - 0.49	0.01	0.01 - 0.02	3 - 8
75% Ar/25%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

FCAW –S ELECTRODE USABILITY DESIGNATION

T-3 ELECTRODES	T-10 ELECTRODES	T-11 ELECTRODES
◆ DC + Polarity ◆ Spray Type Transfer ◆ High Welding Speeds ◆ Single Pass Only ◆ Low Penetration ◆ Sheet Metal Application	◆ DC – Polarity ◆ High Travel Speeds ◆ Single Pass Only ◆ Down Hand Only ◆ Unlimited Material Thickness	◆ DC- Polarity ◆ Spray Type Transfer ◆ General Purpose ◆ All Position ◆ High Speed ◆ Multiple Pass

T-4 ELECTRODES	T-8 ELECTRODES	T-13 ELECTRODES
◆ DC + Polarity ◆ Globular Type Transfer ◆ High Deposition ◆ Low Penetration ◆ Down Hand Only	◆ DC – Polarity ◆ All Position ◆ Multiple Pass ◆ Good Low-Temperature Impacts	◆ DC- Polarity ◆ All Position (Except V-U) ◆ Single Pass Only ◆ For Root Pass on Pipes

T-6 ELECTRODES	T-7 ELECTRODES	T-14 ELECTRODES
◆ DC + Polarity ◆ Spray Type Transfer ◆ Deep Penetration ◆ Good Low Temperature Inputs ◆ Multiple Pass ◆ Down Hand Only	◆ DC – Polarity ◆ High Deposition ◆ Single Pass Only ◆ Down Hand Only (Large Dia) ◆ Multiple All Position (Small Dia) ◆ Multiple Pass	◆ DC- Polarity ◆ All Position (Except VU) ◆ Single Pass Only For Galavanized, Aluminized and Other Coated Steels.



Arc Force Equilibrium

TYPICAL OPERATING PROCEDURES

Diameter, Polarity	CTWD(5) mm (in)	Wire Feed Speed m/min (in/min)	Voltage(4) (volts)	Approx. Current (amps)	Melt-Off Rate kg/hr (lb/hr)	Deposition Rate kg/hr (lb/hr)	Efficiency (%)
0.052 in (1.3 mm), DC+ 75%-85% Ar/ balance CO_2	25 (1)	3.8 (150)	21-26	150	2.0 (4.5)	1.8 (3.9)	86-88
		5.1 (200)	21-27	165	2.7 (6.0)	2.4 (5.2)	
		6.4 (250)	22-27	190	3.4 (7.5)	2.9 (6.5)	
		7.6 (300)	23-28	215	4.1 (9.0)	3.5 (7.8)	
		8.9 (350)	24-29	235	4.7 (10.5)	4.1 (9.1)	
		9.5 (375)	25-30	255	5.1 (11.2)	4.4 (9.8)	
		10.8 (425)	26-31	275	5.8 (12.7)	5.0 (11.1)	
		12.1 (475)	27-32	295	6.4 (14.2)	5.6 (12.4)	
		12.7 (500)	27-33	315	6.8 (15.0)	5.9 (13.0)	
1/16 in (1.6 mm), DC+ 75%-85% Ar/ balance CO_2	25 (1)	3.2 (125)	20-25	185	2.4 (5.3)	2.1 (4.6)	86-88
		4.4 (175)	21-26	215	3.3 (7.4)	2.9 (6.4)	
		5.1 (200)	22-27	235	3.8 (8.4)	3.3 (7.3)	
		5.7 (225)	23-28	265	4.3 (9.5)	3.7 (8.2)	
		6.4 (250)	24-29	285	4.8 (10.5)	4.2 (9.2)	
		7.6 (300)	25-30	315	5.7 (12.6)	5.0 (11.0)	
		8.3 (325)	26-31	335	6.2 (13.7)	5.4 (11.9)	
		8.9 (350)	27-32	365	6.7 (14.7)	5.8 (12.8)	
		10.2 (400)	28-33	385	7.6 (16.8)	6.6 (14.6)	

NOTE 1: FEMA and AWS D1.8 structural steel seismic supplement test data can be found on this product at www.lincolnelectric.com. NOTE 2: This product contains micro-alloying elements. Additional information available upon request.

% Increase in deposition rates in the FLAT/HORIZONTAL positions

T-8 Self-Shielded Wire		Diameters (in.)		
		5/64	0.072	1/16
7018 Stick Electrode Diameters (in.)	3/32	435%	404%	332%
	1/8	270%	249%	199%
	5/32	147%	133%	99%
	3/16	85%	75%	50%
	7/32	48%	40%	20%
	1/4	20%	14%	—

% Increase in deposition rates in the VERTICAL UP/OVERHEAD positions

T-8 Self-Shielded Wire		Diameters (in.)		
		5/64	0.072	1/16
7018 Stick Electrode Diameters (in.)	3/32	306%	278%	230%
	1/8	181%	162%	128%
	5/32	87%	75%	52%
	3/16	40%	31%	14%
	7/32	12%	5%	—