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ARC WELDING ELECTRODES

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ARC WELDING ELECTRODES CAN BE CLASSIFIED INTO TWO BROAD CATEGORIES:

1. Non-Consumable electrodes.
2. Consumable electrodes.

1. Non-Consumable Electrodes:

These electrodes do not consumed during the welding operation, hence they named, non-consumable electrodes. They are generally made of carbon, graphite or tungsten. Carbon electrodes are softer while tungsten and graphite electrodes are hard and brittle.

Carbon and graphite electrodes can be used only for D.C. welding, while tungsten electrodes can be used for both D.C. and A.C. welding. The filler material is added separately when these types of electrodes are used. Since, the electrodes do not consumed, the arc obtained is stable.

2. Consumable Electrodes:

These electrodes get melted during welding operation, and supply the filler material. They are generally made with similar composition as the metal to be welded.

The arc length can be maintained by moving the electrode towards or away from the work.

The consumable electrodes may be of following two types:

(i) Bare Electrodes:

These are available in the form of continuous wire or rods. They must be used only with straight polarity in D.C. welding. Bare electrodes do not provide any shielding to the molten metal pool from atmospheric oxygen and

nitrogen.

Hence, the welds obtained by these electrodes are of lower strength, lower ductility and lower resistance to corrosion. They find limited use in minor repair and poor quality work. They used to weld wrought iron and mild steel. In modern practice they are not used or rarely used. They are also known as plain electrodes.

(ii) Coated Electrodes:

These are sometimes also called as conventional electrodes. A coating (thin layer) of flux material is applied all-round the welding rod, and hence termed as coated electrode. The flux, during welding, provides a shielding to the molten metal zone from the atmospheric oxygen and nitrogen. This flux also prevents formation of oxides and nitrides. Flux chemically react with the oxides present in the metal and forms a low melting temperature fusible slag.

The slag is float on the top of the weld and can easily be brushed off after solidification of weld. The quality of weld produced by coated electrode is much better as compared to that of bare electrodes.

DEPENDING ON THE COATING FACTOR OR THICKNESS OF FLUX COATING, COATED ELECTRODES ARE DIVIDED IN THREE GROUPS:

(a) Lightly coated electrodes.
(b) Medium coated electrodes.
(c) Heavily coated electrodes.

A comparison of three types of coated electrodes is given in the Table 7.10:

Table 7.10. Comparison of Coated electrodes.

S. No.	Basis	Light Coated	Medium Coated	Heavily Coated
1.	Flux coating	Less than 1mm	1 to 1.5mm	1.5 to 3mm
2.	Coating Factor	1.25	1.45	1.6– 2.2
3.	Weight of coating	5 to 10%	10 to 15%	15 to 30%
4.	Weld quality	Poor	improved	Best.

ADVANTAGES OF FLUX COATED ELECTRODES:

The flux coating on welding electrodes has may advantages. Some of them are following:

1. It protects the welding zone from oxidation by providing an atmosphere of inter gas around the arc.

2. It produces low melting temperature slag, which dissolves the impurities present in the metal like oxides and nitrides, and floats on the surface of the weld pool.

3. It refines the grain size of the welded metal.

4. It adds alloying elements to the welded metal.

5. It stabilizes the arc by providing certain chemicals which have this ability.

6. It reduces the spattering of weld metal.

7. It concentrates the arc stream and reduces thermal losses. This result in increased arc temperature.

8. It slows down the cooling rate of weld and accelerates hardening process.

9. It increases the rate of metal deposition and the penetration obtained.

CONSTITUENTS OF ELECTRODE COATINGS:

The electrode coating may consists two or more ingredients. Different type of coatings used for different type of metals to be welded.

The constituents of typical electrode coatings and their functions are given in table 7 11. Some of them are discussed here:

Table. 7.11. Constituents of Electrode Coatings.

Main Function	Constituent	Percentage
Gas generating	Starch Cellulose Calcium carbonate	25-40%
Slag forming	Kaolin Titanium dioxide Fledspar Asbestos	20-40%
Binding	Sodium silicate Potassium silicate	20-30%
Deoxidizing	Ferrosilicon Aluminum	5-10%
Arc stabilizing	Potassium titanate Titanium oxide	5-10%
Increasing deposition rate	Iron powder	0-4%
Improving weld strength	Different alloying elements	5-10%

1. Slag Forming Constituents:

The slag forming ingredients are silicon oxide (Sio_2), Manganese oxide (Mno_2), iron oxide (F_eO), asbestos, mica, etc. In some cases, aluminum oxide (Al_2o_3) is also used but it makes the arc less stable.

2. Constituents to Improve Arc Characteristics:

The ingredients to improve arc characteristics are sodium oxides (Na_2O), Calcium oxides (CaO), magnesium oxides (MgO), and titanium oxide (TIO_2).

3. De-Oxidising Constituents:

The deoxidising ingredients are graphite, powdered aluminum, wood flour, calcium carbonate, starch, cellulose, dolomite, etc.

4. Binding Constituents:

The binding materials used are sodium silicate, potassium silicate and asbestos.

5. Alloying Constituents:

The alloying elements used for improvement of weld strength are vanadium cobalt, molybdenum, aluminum, chromium, nickel, zirconium, tungsten, etc.

SPECIFICATION OF ELECTRODES:

The specification of electrodes are provided by Bureau of Indian standard IS : 815-1974 (second revision).

According to this, the coated electrodes are specified by:

(i) A prefix letter.
(ii) A six digit code number.
(iii) A suffix letter.

Indian system (I.S.) :		L	X	X	X	X	X	X	L
		1st Letter	1st	2nd	3rd	4th	5th	6th	Last Letter
			Digits						
Example	IS : 815 coading	:	E 314 – 411 K						
	Specification	:	Ref. IS : 814 (Part–I)						

(i) Prefix Letter:

The prefix letter indicates the method of manufacturing of electrodes.

These prefix letters with method of manufacturing of electrodes are given in the Table 7.12:

Table. 7.12. Meaning of prefix letters.

Prefix letter	Method of Manufacturing
E	Solid extrusion process.
R	Extruded with reinforcement.

(ii) A Six Digit Code Number:

The six digit code number indicated the performance characteristics and mechanical properties of the weld metal deposit.

The meaning of each individual digit from one to six is given in the Table 7.13:

Table. 7.13. Meaning of individual digit in code number.

Digit	Meaning	
First digit	(*i*) Type of covering	Performance characteristics
Second digit	(*ii*) Welding position in which the electrode may be used.	
Third digit	(*iii*) Welding current condition.	Mechanical properties and weld metal deposit.
Fourth digit	(*iv*) Range of tensile strength	
Fifth digit	(*v*) Range of Yield strength	
Sixth digit	(*vi*) Percentage elongation along with the impact value of deposit metal.	

(iii) Suffix Letter:

The suffix letter indicates the special properties or characteristics of the electrode.

These are given in the Table 7.14:

Table. 7.14 Meaning of suffix letters.

Suffix letter	Special Properties/characterstics
H	Hydrogen controlled electrode.
J	Iron powder covering, giving metal recovery of 110–130% inclusive.
K	Iron powder covering, giving metal recovery of 130–150%.
P	Deep Penetration.

The first digits of the code number essentially explain the type of covering used on the electrode and this covering signifies the performance characteristics.

There are seven types of covering representing the first digit number are given in the Table 7.15:

Table. 7.15. Types of first digit numbers used.

First digit number of code	Types of Covering
1	High cellulose contents.
2	High contents of titanium along with ionizing producing a fairly viscous slag.
3	Appreciable amount of titanium with basic materials producing a fluid slag.
4	High contents of oxides or silicates, both of iron and manganese, producing an inflated slag.
5	High contents of iron oxide or silicate or both producing a solid slag.
6	High contents of calcium carbonate and fluoride.
7	Any other material, not specified above.

The second digit of the code indicates the welding position, as per Table 7.16 given below:

Table. 7.16. Types of second digit numbers used.

Second digit number of code	Welding position	Letter symbol stands for
O	F, H, V, D, O	F – Flat
1	F, H, V, O	H – Horizontal
2	F, H	V – Vertical-up
3	F	D – Vertical-down
4	F, H_f	O – Over head.
9	Any other position not clarified above.	

The third digit of the code number indicates welding current conditions recommended by the manufacturer of electrode.

These are given in the Table 7.17:

Table 7.17. Types of third digit numbers used.

Third digit number of code	Welding current conditions
0	D +
1	D +, A90
2	D –, A70
3	D –, A50
4	D +, A70
5	D ±, A90
6	D ±, A70
7	D ±, A90
9	Any other current conditions not specified above.

Notetions used : D + D.C. with electrode positive.
D – D.C. with electrode negative.
D ± D.C. with electrode positive or negative.
A 90, A 70, A 50 A.C. with open circuit voltage not less than 90 volts, 70 volts and 50 volts, respectivety.

The fourth, fifth and sixth digits of the code number represents tensile strength, maximum yield stress and percentage elongation with impact value.

These are given in the Table 7.18:

Table. 7.18. Types of fourth, fifth and sixth digits used.

Electrode Classfication	Tensile strength (N/mm^2)	Max-yield stress (N/mm^2)	Min-elongation in % of gauge length of $5.65\sqrt{S_o}$ value	Temperature for minium value of 47J°C
EXXX—410	410–510	330	—	—
EXXX—411	410–510	330	20	+27
EXXX—412	410–510	330	22	0
EXXX—413	410–510	330	24	–20
EXXX—414	410–510	330	24	–30
EXXX—415	410–510	330	24	–40
EXXX—510	510–610	360	—	—
EXXX—511	510–610	360	18	+27
EXXX—512	510–610	360	18	0
EXXX—513	510–610	360	20	–20
EXXX—514	510–610	360	—	–30
EXXX—515	510–610	360	—	–40

In addition to the coding given above, all electrodes must conform to the test requirements of IS: 814 (part I and II)

– 1974. Each packet of electrodes must have a marking indicating coding and specification.

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