LESSON PLAN

Date_______________ Trade:- Welder

Name_____________ Week No:- sixteen

Subject :- Electrodes, types, function of flux, coating factor, sizes of electrode. Coding of electrodes as per BIS, AWS. Moisture pick up of electrode. Storage and baking of electrodes. Special purpose electrode and their application.

Motivations:- in previous week we learned about Gas Welding Filler rods, specification and sizes. Gas welding flux-types and functions. Gas brazing and soldering, principles, types fluxes & uses. Gas welding defects causes and remedies.

PREPARATION: - Teaching Aids:-Chalk, Charts,

INTRODUCTION: -Electrode is used in electric welding for supply current and fill the joint. The composition of electrode effects the joint so we must have knowledge about electrode before welding.

PRESENTATION:-

Topic	Information Point	Spot Hint

An electrode is a metal wire that is coated. It is made out of materials with a similar composition to the metal being welded. There are a variety of factors that go into choosing the right electrode for each project. SMAW or stick electrodes are consumable, meaning they become part of the weld, while TIG electrodes are non-consumable as they do not melt and become part of the weld, requiring the use of a welding rod.The MIG welding electrode is a continuously fed wire referred to as wire.Electrode selection is critical to ease of cleanup, weld strength, bead quality and for minimizing any spatter. Electrodes need to be stored in a moisture free environment and carefully removed from any package (follow the directions to avoid damage).

Covered Welding Electrodes

When molten metal is exposed to air, it absorbs oxygen and nitrogen, and becomes brittle or is otherwise adversely affected.

A slag cover is needed to protect molten or solidifying weld metal from the atmosphere. This cover can be obtained from the electrode coating.

The composition of the welding electrode coating determines its usability, as well as the composition of the deposited weld metal and the electrode specification.

The formulation of Welding electrode coatings is based on well-established principles of metallurgy, chemistry, and physics. The coating protects the metal from damage, stabilizes the arc, and improves the weld in other ways, which include:

1. Smooth weld metal surface with even edges.
2. Minimum spatter adjacent to the weld.

3. A stable welding arc.
4. Penetration control.
5. A strong, tough coating.
6. Easier slag removal.
7. Improved deposition rate.

The metal-arc electrodes may be grouped and classified as bare or thinly coated electrodes, and shielded arc or heavy coated electrodes. The covered electrode is the most popular type of filler metal used in arc welding. The composition of the electrode covering determines the usability of the electrode, the composition of the deposited weld metal, and the specification of the electrode. The type of electrode used depends on the specific properties required in the weld deposited. These include corrosion resistance, ductility, high tensile strength, the type of base metal to be welded, the position of the weld (flat, horizontal, vertical, or overhead); and the type of current and polarity required.

Popular Welding Electrode (E6010) used for general purpose fabrication, construction, pipe welding, and shipbuilding

Classification

The American Welding Society's classification number series for welding electrodes has been adopted by the welding industry. The electrode identification system for steel arc welding is set up as follows:

1. E indicates electrode for arc welding.
2. The first two (or three) digits indicate tensile strength (the resistance of the material to forces trying to pull it apart) in thousands of pounds per square inch of the deposited metal.
3. The third (or fourth) digit indicates the position of the weld. 0 indicates the classification is not used; 1 is for all positions; 2 is for flat and horizontal positions only; 3 is for flat position only.
4. The fourth (or fifth) digit indicates the type of electrode coating and the type of power supply used; alternating or direct current, straight or reverse polarity.
5. The types of coating, welding current, and polarity position designated by the fourth (or fifth) identifying digit of the electrode classification are as listed in table 5-4.
6. 6) The number E6010 indicates an arc welding electrode with a minimum stress relieved tensile strength of 60,000 psi; is used in all positions; and reverse polarity direct current is required.

Coating, Current and Polarity Types Designated By the Fourth Digit in the Electrode Classification Number

Digit	Coating	Weld Current
0	*	*
1	Cellulose Potassium	ac, dcrp, dcsp
2	Titania sodium	ac, dcsp
3	Titania potassium	ac, dcsp, dcrp
4	Iron Powder Titania	ac, dcsp, dcrp
5	Low hydrogen sodium	dcrp
6	Low hydrogen potassium	ac, dcrp
7	Iron powder iron oxide	ac, dcsp
8	Iron powder low hydrogen	ac, dcrp, dcsp

When the fourth (or last) digit is 0, the type of coating and current to be used are determined by the third digit.

The welding electrode identification system for stainless steel arc welding is set up as follows:

1. E indicates electrode for arc welding.
2. The first three digits indicated the American Iron and Steel type of stainless steel.
3. The last two digits indicate the current and position used.
4. The number E-308-16 by this system indicates stainless steel Institute type 308; used in all positions; with alternating or reverse polarity direct current.

Classification System for Submerged Arc Electrodes

The system for identifying solid bare carbon steel for submerged arc is as follows:

1. The prefix letter E is used to indicate an electrode. This is followed by a letter which indicates the level of manganese, i.e., L for low, M for medium, and H for high manganese. This is followed by a number which is the average amount of carbon in points or hundredths of a percent. The composition of some of these wires is almost identical with some of the wires in the gas metal arc welding specification.
2. The electrode wires used for submerged arc welding are given in American Welding Society specification, "Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding." This specification provides both the wire composition and the weld deposit chemistry based on the flux used. The specification does give composition of the electrode wires. When these electrodes are used with specific submerged arc fluxes and welded with proper procedures, the deposited weld metal will meet mechanical properties required by the specification.
3. In the case of the filler reds used for oxyfuel gas welding, the prefix letter is R, followed by a G indicating that the rod is used expressly for gas welding. These letters are followed by two digits which will be 45, 60, or 65. These designate the approximate tensile strength in 1000 psi (6895 kPa).
4. In the case of nonferrous filler metals, the prefix E, R, or RB is used, followed by the chemical symbol of the principal metals in the wire. The initials for one or two elements will follow. If there is more than one alloy containing the same elements, a suffix letter or number may be added.
5. The American Welding Society's specifications are most widely used for specifying bare welding rod and electrode wires. There are also military specifications such as the MIL-E or -R types and federal specifications, normally the QQ-R type and AMS specifications. The particular specification involved should be used for specifying filler metals.

The most important aspect of solid welding electrode wires and rods in their composition, which is given by the specification. The specifications provide the limits of composition for the different wires and mechanical property requirements.

Occasionally, on copper-plated solid wires, the copper may flake off in the feed roll mechanism and create problems. It may plug liners, or contact tips. A light copper coating is desirable. The electrode wire surface should be reasonably free of dirt and drawing compounds. This can be checked by using a white cleaning tissue and pulling a length of wire through it. Too much dirt will clog the liners, reduce current pickup in the tip, and may create erratic welding operation.

Temper or strength of the wire can be checked in a testing machine. Wire of a higher strength will feed through guns and cables better. The minimum tensile strength recommended by the specification is 140,000 psi (965,300 kPa).

The continuous electrode wire is available in many different packages. They range from extremely small spools that are used on spool guns, through medium-size spools for fine-wire gas metal arc welding. Coils of electrode wire are available which can be placed on reels that are a part of the welding equipment. There are also extremely large reels weighing many hundreds of pounds. The electrode wire is also available in drums or payoff packs where the wire is laid in the round container and pulled from the container by an automatic wire feeder.

Coatings

The coatings of welding electrodes for welding mild and low alloy steels may have from 6 to 12 ingredients, which includes:

- cellulose to provide a gaseous shield with a reducing agent in which the gas shield surrounding the arc is produced by the disintegration of cellulose
- metal carbonates to adjust the basicity of the slag and to provide a reducing atmosphere
- titanium dioxide to help form a highly fluid, but quick-freezing slag and to provide ionization for the arc
- ferromanganese and ferrosilicon to help deoxidize the molten weld metal and to supplement the manganese content and silicon content of the deposited weld metal
- clays and gums to provide elasticity for extruding the plastic coating material and to help provide strength to the coating
- calcium fluoride to provide shielding gas to protect the arc, adjust the basicity of the slag, and provide fluidity and solubility of the metal oxides
- mineral silicates to provide slag and give strength to the electrode covering
- alloying metals including nickel, molybdenum, and chromium to provide alloy content to the deposited weld metal
- iron or manganese oxide to adjust the fluidity and properties of the slag and to help stabilize the arc
- iron powder to increase the productivity by providing extra metal to be deposited in the weld.

The principal types of welding electrode coatings for mild steel and are described below.

1. **Cellulose-sodium (EXX10)**: Electrodes of this type cellulosic material in the form of wood flour or reprocessed low alloy electrodes have up to 30 percent paper. The gas shield contains carbon dioxide and hydrogen, which are reducing agents. These gases tend to produce a digging arc that provides deep penetration. The weld deposit is somewhat rough, and the spatter is at a higher level than other electrodes. It does provide extremely good mechanical properties, particularly after aging. This is one of the earliest types of electrodes developed, and is widely used for cross country pipe lines using the downhill welding technique. It is normally used with direct current with the electrode positive (reverse polarity).
2. **Cellulose-potassium (EXX11)**: This electrode is very similar to the cellulose-sodium electrode, except more potassium is used than sodium. This provides ionization of the arc and makes the electrode suitable for welding with alternating current. The arc action, the penetration, and the weld results are very similar. In both E6010 and E6011 electrodes, small amounts of iron powder may be added. This assists in arc stabilization and will slightly increase the deposition rate.
3. **Rutile-sodium (EXX12)**: When rutile or titanium dioxide content is relatively high with respect to the other components, the electrode will be especially appealing to the welder. Electrodes with this coating have a quiet arc, an easily controlled slag, and a low level of spatter. The weld deposit will have a smooth surface and the penetration will be less than with the cellulose electrode. The weld metal properties will be slightly lower than the cellulosic types. This type of electrode provides a fairly high rate of deposition. It has a relatively low arc voltage, and can be used with alternating current or with direct current with electrode negative (straight polarity).
4. **Rutile-potassium (EXX13)**: This electrode coating is very similar to the rutile-sodium type, except that potassium is used to provide for arc ionization. This makes it more suitable for welding with alternating current. It can also be used with direct current with either polarity. It produces a very quiet, smooth running arc.
5. **Rutile-iron powder (EXXX4)**: This coating is very similar to the rutile coatings mentioned above, except that iron powder is added. If iron content is 25 to 40 percent, the electrode is EXX14. If iron content is 50 percent or more, the electrode is EXX24.

With the lower percentage of iron powder, the electrode can be used in all positions. With the higher percentage of iron paler, it can only be used in the flat position or for making horizontal fillet welds. In both cases, the deposition rate is increased, based on the amount of iron powder in the coating.

6. **Low hydrogen-sodium (EXXX5)**: Coatings that contain a high proportion of calcium carbonate or calcium fluoride are called low hydrogen, lime ferritic, or basic type electrodes. In this class of coating, cellulose, clays, asbestos, and other minerals that contain combined water are not used. This is to ensure the lowest possible hydrogen content in the arc atmosphere. These electrode coatings are baked at a higher temperature. The low hydrogen electrode family has superior weld metal properties. They provide the highest ductility of any of the deposits. These electrodes have a medium arc with medium or moderate penetration. They have a medium speed of deposition, but require special welding techniques for best results. Low hydrogen electrodes must be stored under controlled conditions. This type is normally used with direct current with electrode positive (reverse polarity).
7. **Low hydrogen-potassium (EXXX6)**: This type of coating is similar to the low hydrogen-sodium, except for the substitution of potassium for sodium to provide arc ionization. This electrode is used with alternating current and can be used with direct current, electrode positive (reverse polarity). The arc action is smother, but the penetration of the two electrodes is similar.
8. **Low hydrogen-potassium (EXXX6)**: The coatings in this class of electrodes are similar to the low-hydrogen type mentioned above. However, iron powder is added to the electrode, and if the content is higher than 35 to 40 percent, the electrode is classified as an EXX18.
9. **Low hydrogen-iron powder (EXX28)**: This electrode is similar to the EXX18, but has 50 percent or more iron powder in the coating. It is usable only when welding in the flat position or for making horizontal fillet welds. The deposition rate is higher than EXX18. Low hydrogen coatings are used for all of the higher-alloy electrodes. By additions of specific metals in the coatings, these electrodes become the alloy types where suffix letters are used to indicate weld metal compositions. Electrodes for welding stainless steel are also the low-hydrogen type.
10. **Iron oxide-sodium (EXX20)**: Coatings with high iron oxide content produce a weld deposit with a large amount of slag. This can be difficult to control. This coating type produces high-speed deposition, and provides medium penetration with low spatter level. The resulting weld has a very smooth finish. The electrode is usable only with flat position welding and for making horizontal fillet welds. The electrode can be used with alternating current or direct current with either polarity.
11. **Iron-oxide-iron power (EXX27)**: This type of electrode is very similar to the iron oxide-sodium type, except it contains 50 percent or more iron power. The increased amount of iron power greatly increases the deposition rate. It may be used with alternating direct current of either polarity.

There are many types of coatings other than those mentioned here, most of which are usually combinations of these types but for special applications such as hard surfacing, cast iron welding, and for nonferrous metals.

Storage Electrodes must be kept dry. Moisture destroys the desirable characteristics of the coating and may cause excessive spattering and lead to porosity and cracks in the the formation of the welded area. Electrodes exposed to damp air for more than two or three hours should be dried by heating in a suitable oven (fig 5-32) for two hours at 500°F (260°C).

After they have dried, they should be stored in a moisture proof container. Bending the electrode can cause the coating to break loose from the core wire. Electrodes should not be used if the core wire is exposed.

Electrodes that have an "R" suffix in the AWS classification have a higher resistance to moisture.

The Types of Electrodes

Bare Electrodes

Bare welding electrodes are made of wire compositions required for specific applications. These electrodes have no coatings other than those required in wire drawing. These wire drawing coatings have some slight stabilizing effect on the arc but are otherwise of no consequence. Bare electrodes are used for welding manganese steel and other purposes where a coated electrode is not required or is undesirable.

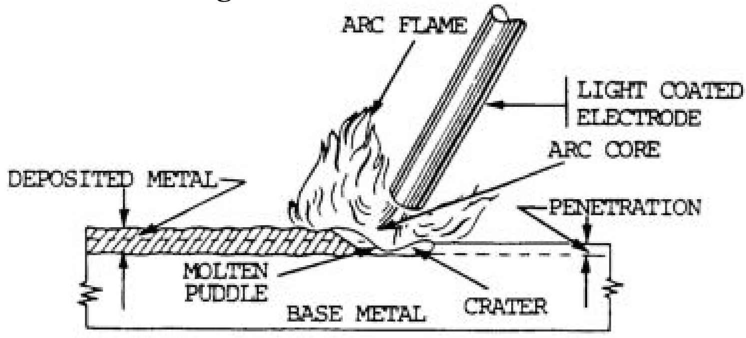
Light Coated Electrodes

Light coated welding electrodes have a definite composition. A light coating has been applied on the surface by washing, dipping, brushing, spraying, tumbling, or wiping. The coatings improve the characteristics of the arc stream. They are listed under the E45 series in the electrode identification system.

The coating generally serves the functions described below:

1. It dissolves or reduces impurities such as oxides, sulfur, and phosphorus.
2. It changes the surface tension of the molten metal so that the globules of metal leaving the end of the electrode are smaller and more frequent. This helps make flow of molten metal more uniform.
3. It increases the arc stability by introducing materials readily ionized (i.e., changed into small particles with an electric charge) into the arc stream.
4. Some of the light coatings may produce a slag. The slag is quite thin and does not act in the same manner as the shielded arc electrode type slag.

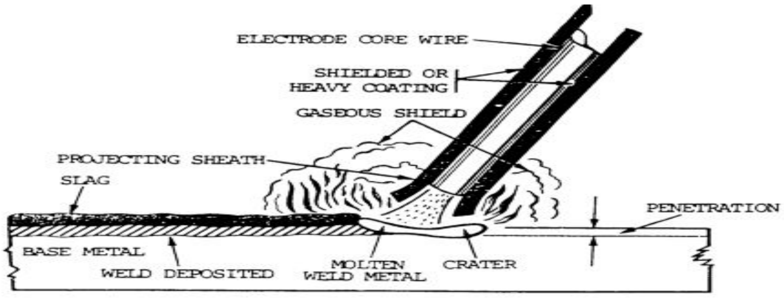
Light Coated Electrode



Shielded Arc or Heavy Coated Electrodes

Shielded arc or heavy coated welding electrodes have a definite composition on which a coating has been applied by dipping or extrusion. The electrodes are manufactured in three general types: those with cellulose coatings; those with mineral coatings; and those whose coatings are combinations of mineral and cellulose. The cellulose coatings are composed of soluble cotton or other forms of cellulose with small amounts of potassium, sodium, or titanium, and in some cases added minerals. The mineral coatings consist of sodium silicate, metallic oxides clay, and other inorganic substances or combinations thereof. Cellulose coated electrodes protect the molten metal with a gaseous zone around the arc as well as the weld zone. The mineral coated electrode forms a slag deposit. The shielded arc or heavy coated electrodes are used for welding steels, cast iron, and hard surfacing. See figure 5-31 below.

Shielded Arc Electrode



Functions of Shielded Arc or Heavy Coated Electrodes

These welding electrodes produce a reducing gas shield around the arc. This prevents atmospheric oxygen or nitrogen from contaminating the weld metal. The oxygen readily combines with the molten metal, removing alloying elements and causing porosity. Nitrogen causes brittleness, low ductility, and in Some cases low strength and poor resistance to corrosion.

They reduce impurities such as oxides, sulfur, and phosphorus so that these impurities will not impair the weld deposit.

They provide substances to the arc which increase its stability. This eliminates wide fluctuations in the voltage so that the arc can be maintained without excessive spattering.

By reducing the attractive force between the molten metal and the end of the electrodes, or by reducing the surface tension of the molten metal, the vaporized and melted coating causes the molten metal at the end of the electrode to break up into fine, small particles.

The coatings contain silicates which will form a slag over the molten weld and base metal. Since the slag solidifies at a relatively slow rate, it holds the heat and allows the underlying metal to cool and solidify slowly. This slow solidification of the metal eliminates the entrapment of gases within the weld and permits solid impurities to float to the surface. Slow cooling also has an annealing effect on the weld deposit.

The physical characteristics of the weld deposit are modified by incorporating alloying materials in the electrode coating. The fluxing action of the slag will also produce weld metal of better quality and permit welding at higher speeds.

Tungsten Electrodes

Non consumable welding electrodes for gas tungsten-arc (TIG) welding are of three types: pure tungsten, tungsten containing 1 or 2 percent thorium, and tungsten containing 0.3 to 0.5 percent zirconium. Tungsten electrodes can be identified as to type by painted end marks as follows.

1. Green -- pure tungsten.
2. Yellow -- 1 percent thorium.
3. Red -- 2 percent thorium.
4. Brown -- 0.3 to 0.5 percent zirconium.

Pure tungsten (99. 5 percent tungsten) electrodes are generally used on less critical welding operations than the tungstens which are alloyed. This type of electrode has a relatively low current-carrying capacity and a low resistance to contamination.

Thoriated tungsten electrodes (1 or 2 percent thorium) are superior to pure tungsten electrodes because of their higher electron output, better arc-starting and arc stability, high current-carrying capacity, longer life, and greater resistance to contamination.

Tungsten welding electrodes containing 0.3 to 0.5 percent zirconium generally fall between pure tungsten electrodes and thoriated tungsten electrodes in terms of performance. There is, however, some indication of better performance in certain types of welding using ac power.

Finer arc control can be obtained if the tungsten alloyed electrode is ground to a point (see figure 5-33). When electrodes are not grounded, they must be operated at maximum current density to obtain reasonable arc stability. Tungsten electrode points are difficult to maintain if standard direct current equipment is used as a power source and touch-starting of the arc is standard practice. Maintenance of electrode shape and the reduction of tungsten inclusions in the weld can best be accomplished by superimposing a high-frequency current on the regular welding current. Tungsten electrodes alloyed with thorium and zirconium retain their shape longer when touch-starting is used.

The welding electrode extension beyond the gas cup is determined by the type of joint being welded. For example, an extension beyond the gas cup of 1/8 in. (3.2 mm) might be used for butt joints in light gage material, while an extension of approximately 1/4 to 1/2 in. (6.4 to 12.7 mm) might be necessary on some fillet welds. The tungsten electrode of torch should be inclined slightly and the filler metal added carefully to avoid contact with the tungsten. This will prevent contamination of the electrode. If contamination does occur, the electrode must be removed, reground, and replaced in the torch.

Direct Current Arc Welding Electrodes

The manufacturer's recommendations should be followed when a specific type of welding electrode is being used. In general, direct current shielded arc electrodes are designed either for reverse polarity (electrode positive) or for straight polarity (electrode negative), or both. Many, but not all, of the direct current electrodes can be used with alternating current. Direct current is preferred for many types of covered, nonferrous, bare and alloy steel electrodes. Recommendations from the manufacturer also include the type of base metal for which given electrodes are suited, corrections for poor fit-ups, and other specific conditions.
In most cases, straight polarity electrodes will provide less penetration than reverse polarity electrodes, and for this reason will permit greater welding speed. Good penetration can be obtained from either type with proper welding conditions and arc manipulation.

Alternating Current Arc Welding Electrodes

Coated electrodes which can be used with either direct or alternating current are available. Alternating current is more desirable while welding in restricted areas or when using the high currents required for thick sections because it reduces arc blow. Arc blow causes blowholes, slag inclusions, and lack of fusion in the weld.
Alternating current is used in atomic hydrogen welding and in those carbon arc processes that require the use of two carbon electrodes. It permits a uniform rate of welding and electrode consumption. In carbon-arc processes where one carbon electrode is used, direct current straight polarity is recommended, because the electrode will be consumed at a lower rate.

Electrode Defects and Their Effects

If certain elements or oxides are present in electrode coatings, the arc stability will be affected. In bare electrodes, the composition and uniformity of the wire is an important factor in the control of arc stability. Thin or heavy coatings on the electrodes will riot completely remove the effects of defective wire.
Aluminum or aluminum oxide (even when present in 0.01 percent), silicon, silicon dioxide, and iron sulphate unstable. Iron oxide, manganese oxide, calcium oxide, and stabilize the arc. When phosphorus or sulfur are present in the electrode in excess of 0.04 percent, they will impair the weld metal because they are transferred from the electrode to the molten metal with very little loss. Phosphorus causes grain growth, brittleness, and "cold shortness" (i. e., brittle when below red heat) in the weld. These defects increase in magnitude as the carbon content of the steel increases. Sulfur acts as a slag, breaks up the soundness of the weld metal, and causes "hot shortness" (i. e., brittle when above red heat). Sulfur is particularly harmful to bare, low-carbon steel electrodes with a low manganese content. Manganese promotes the formation of sound welds.
If the heat treatment, given the wire core of an electrode, is not uniform, the electrode will produce welds inferior to those produced with an electrode of the same composition that has been properly heat treated.

Deposition Rates

The different types of electrodes have different deposition rates due to the composition of the coating. The electrodes containing iron power in the coating have the highest deposition rates. In the United States, the percentage of iron power in a coating is in the 10 to 50 percent range. This is based on the amount of iron power in the coating versus the coating weight. This is shown in the formula:

$$\%\ \text{Iron powder} = \frac{\text{Weight of iron powder}}{\text{Total weight of coating}} \times 100$$

These percentages are related to the requirements of the American Welding Society (AWS) specifications. The European method of specifying iron power is based on the weight of deposited weld metal versus the weight of the bare core wire consumed. This is shown as follows:

$$\% \text{ Iron powder} = \frac{\text{Weight of deposited metal}}{\text{Weight of bare core wire}} \times 100$$

Thus, if the weight of the deposit were double the weight of the core wire, it would indicate a 200 percent deposition efficiency, even though the amount of the iron power in the coating represented only half of the total deposit. The 30 percent iron power formula used in the United States would produce a 100 to 110 percent deposition efficiency using the European formula. The 50 percent iron power electrode figured on United States standards would produce an efficiency of approximately 150 percent using the European formula.

Non-consumable Electrodes

Types

There are two types of nonconsumable welding electrodes.

1. The carbon electrode is a non-filler metal electrode used in arc welding or cutting, consisting of a carbon graphite rod which may or may not be coated with copper or other coatings.
2. The tungsten electrode is defined as a non-filler metal electrode used in arc welding or cutting, made principally of tungsten.

Carbon Electrodes

The American Welding Society does not provide specification for carbon welding electrodes but there is a military specification, no. MIL-E-17777C, entitled, "Electrodes Cutting and Welding Carbon-Graphite Uncoated and Copper Coated".

This specification provides a classification system based on three grades: plain, uncoated, and copper coated. It provides diameter information, length information, and requirements for size tolerances, quality assurance, sampling, and various tests. Applications include carbon arc welding, twin carbon arc welding, carbon cutting, and air carbon arc cutting and gouging.

Stick Electrodes

Stick welding electrodes vary by:

- **size**: common sizes are 1⁄16, 5⁄64, 3⁄32 (most common), 1⁄8, 3⁄16, 7⁄32, 1⁄4, and 5⁄16 inch. Core wire used with electrodes needs to be narrower than the materials that are welded.
- **material**: stick welding electrodes come in cast iron, high carbon steel, mild steel, iron-free (nonferrous) and special alloys.)
- **strength**: referred to as tensile strength. Each weld needs to be stronger than the metal being welded. This means that the materials in the electrode need to be stronger as well.
- **welding position** (horizontal, flat etc): different electrodes are used for each welding position.
- **iron powder mix** (up to 60% in flux): iron powder in the flux increases the amount of molten metal available for the weld (heat turns powder into steel).
- **soft arc designation**: for thinner metals or for metals that don't have a perfect fit or gap. As described above there are many kinds of electrodes. Here are the most popular stick welding (SMAW) electrodes:

- E6013 and E6012: For thin metals and joints that do not easily fit together.
- E6011: Good for working on surfaces that are oily, rusted or has dirt. Versatile in that it works with DC or AC polarity. Creates little slag, another big plus. Note that this electrode should not be placed into an electrode oven.
- E6010: Similar to the E6011 but only works with direct current (DC). Note that this electrode should not be placed into an electrode oven.
- E76018 and E7016: Manufactured with iron powder in the flux. Creates strong welds, but has a puddle that might present some control issues for beginners.

Electrodes for Shielded Metal Arc Welding (SMAW) or stick electrodes must be properly stored in order to deposit quality welds. When stick electrodes absorb moisture from the atmosphere, they must be dried in order to restore their ability to deposit quality welds. Electrodes with too much moisture may lead to cracking or porosity. Operational characteristics may be affected as well. If you've experienced unexplained weld cracking problems, or if the stick electrode arc performance has deteriorated, it may be due to your storage methods or re-drying procedures.

Follow these simple storage, exposure and redrying techniques to ensure the highest quality welds, as well as the best operational characteristics from your stick electrodes.

Storing Low Hydrogen Stick Electrodes

Low hydrogen stick electrodes must be dry to perform properly. Unopened Lincoln hermetically sealed containers provide excellent protection in good storage conditions. Opened cans should be stored in a cabinet at 250 to 300°F (120 to 150°C) Low hydrogen stick electrode coatings that have picked up moisture may result in hydrogen induced cracking, particularly in steels with a yield strength of 80,000 psi (550 MPa) and higher.

Moisture resistant electrodes with an "R" suffix in their AWS classification have a high resistance to moisture pickup coating and, if properly stored, will be less susceptible to this problem, regardless of the yield strength of the steel being welded. Specific code requirements may indicate exposure limits different from these guidelines.

All low hydrogen stick electrodes should be stored properly, even those with an "R" suffix. Standard EXX18 electrodes should be supplied to welders twice per shift. Moisture resistant types may be exposed for up to 9 hours.

When containers are punctured or opened, low hydrogen electrodes may pick up moisture. Depending upon the amount of moisture, it will damage weld quality in the following ways:

1. A greater amount of moisture in low hydrogen electrodes may cause porosity. Detection of this condition requires x-ray inspection or destructive testing. If the base metal or weld metal exceeds 80,000 psi (550 MPa) yield strength, this moisture may contribute to under-bead or weld cracking.
2. A relatively high amount of moisture in low hydrogen electrodes causes visible external porosity in addition to internal porosity. It also may cause excessive slag fluidity, a rough weld surface, difficult slag removal, and cracking.
3. Severe moisture pickup can cause weld cracks in addition to under-bead cracking, severe porosity, poor appearance and slag problems.

Redrying Low Hydrogen Stick Electrodes

Redrying, when done correctly, restores the electrodes' ability to deposit quality welds. Proper redrying temperature depends upon the electrode type and its condition.

One hour at the listed final temperature is satisfactory. DO NOT dry electrodes at higher temperatures. Several hours at lower temperatures is not equivalent to using the specified requirements.

Electrodes of the E8018 and higher strength classifications should be given no more than three one-hour re-dries in the 700 to 800°F (370 to 430°C) range. This minimizes the possibility of oxidation of alloys in the coating resulting in lower than normal tensile or impact properties.

Any low hydrogen electrode should be discarded if excessive redrying causes the coating to become fragile and flake or break off while welding, or if there is a noticeable difference in handling or arc characteristics, such as insufficient arc force.

Electrodes to be redried should be removed from the can and spread out in the oven because each electrode must reach the drying temperature.

		Final Redrying Temperature	
Condition	**Pre-drying Temperature(1)**	**E7018, E7028**	**E8018, E9018, E10018, E11018**
Electrodes exposed to air for less than one week; no direct contact with water.	N/A	650 to 750°F (340 to 400°C)	700 to 800°F (370 to 430°C)
Electrodes which have come in direct contact with water or which have been exposed to high humidity.	180 to 220°F (80 to 105°C)	650 to 750°F (340 to 400°C)	700 to 800°F (370 to 430°C)

(1) Pre-dry for 1 to 2 hours. This will minimize the tendency for coating cracks or oxidation of the alloys in the coating.

Storing and Redrying Non-Low Hydrogen Electrodes

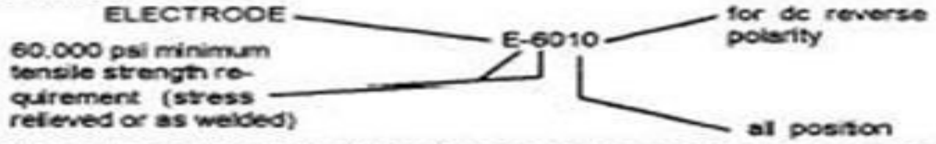
Electrodes in unopened Lincoln cans or cartons retain the proper moisture content indefinitely when stored in good condition.

If exposed to humid air for long periods of time, stick electrodes from opened containers may pick up enough moisture to affect operating characteristics or weld quality. If moisture appears to be a problem, store electrodes from the opened containers in heated cabinets at 100 to 120°F (40 to 50°C). DO NOT use higher temperatures, particularly for electrodes from the "Fast Freeze" group.Some electrodes from wet containers or long exposure to high humidity can be re-dried. Adhere to the procedures in the following table for each type.

All mild steel and low-alloy electrodes are classified with a 4 or 5 digit number prefixed by "E."
Prefix "E" = Electrode
First two (or three) digits = Tensile strength (psi) (stress relieved or as welded)
Third (or fourth) digit = Position of welding
1 = all positions (flat, horizontal, vertical, overhead)
2 = horizontal and flat positions only

FOURTH DIGIT	TYPE OF COATING	WELDING CURRENT
1	cellulose potassium	ac or dc Reverse or Straight
2	titania sodium	ac or dc Straight
3	titania potassium	ac or dc Straight or Reverse
4	iron powder titania	ac or dc Straight or Reverse
5	low hydrogen sodium	dc Reverse
6	low hydrogen potassium	dc or dc Reverse
7	iron powder iron oxide	ac or dc
8	iron powder low hydrogen	dc Reverse or Straight or ac
0*	see reference below	

EXAMPLE



*When the fourth digit is 0, the type of coating and current to use are determined by the third digit. For example, E-6010 indicates a cellulose sodium coating and operates on dc reverse, while E-6020 has an iron oxide coating and operates on ac or dc.

Redrying Conditions - Non-Low Hydrogen Stick Electrodes

Stick Electrode	Electrode Group	Final Redrying Temperature	Time
E6010: Fleetweld 5P, 5P+ E6011: Fleetweld 35, 35LS, 180 E7010-A1: SA-85(1) E7010-G: SA-HYP+(1) E8010-G: SA-70+(1), SA-80(1) E9010-G: SA-90(1)	**Fast Freeze** - excessive moisture is indicated by a noisy arc and high spatter, rusty core wire at the holder end or objectionable coating blisters while welding. **Re-baking of this group of stick electrodes is not recommended.**	Not Recommended	N/A

E7024: Jetweld 1, 3 E6027: Jetweld 2	**Fast Fill** - excessive moisture is indicated by a noisy or "digging" arc, high spatter, tight slag, or undercut. Pre-dry unusually damp electrodes for 30 - 45 minutes at 200°F to 230°F (90 - 110°C) before final drying to minimize cracking of the coating.	400 to 500°F (200to 260°C)	30 - 45 minutes
E6012: Fleetweld 7 E6013: Fleetweld 37 E7014: Fleetweld 47 E6022: Fleetweld 22	**Fill Freeze** - Excessive moisture is indicated by a noisy or "digging" arc, high spatter, tight slag or undercut. Pre-dry unusually damp electrodes for 30 - 45 minutes at 200° - 230°F (90° - 110°C) before final drying to minimize cracking of the coating	300 to 350°F (150 to 180°C)	20 - 30 minutes

(1) Pre-dry for 1 to 2 hours. This will minimize the tendency for coating cracks or oxidation of the alloys in the coating.

Using longer drying times or higher temperatures can easily damage the electrodes. For drying, remove the electrodes from the container and spread them out in the furnace because each stick electrode must reach the drying temperature.

Standard Number	Title
AWS A2.4	Standard symbols for welding, brazing, and non-destructive examination
AWS A3.0	Standard welding terms and definitions
AWS A5.1	Specification for carbon steel electrodes for shielded metal arc welding
AWS A5.18	Specification for carbon steel electrodes and rods for gas shielded arc welding
AWS B2.1	Specification for Welding Procedure and Performance Qualification
AWS B1.10	Guide for the nondestructive examination of welds
AWS D1.1	Structural welding (steel)
AWS D1.2	Structural welding (aluminum)
AWS D1.3	Structural welding (sheet steel)
AWS D1.4	Structural welding (reinforcing steel)
AWS D1.5	Bridge welding
AWS D1.6	Structural welding (stainless steel)
AWS D1.7	Structural welding (strengthening and repair)
AWS D1.8	Structural welding seismic supplement
AWS D1.9	Structural welding (titanium)
AWS D8.1	Automotive spot welding
AWS D8.14	Automotive arc welding (aluminum)

AWS D8.6	Automotive spot welding electrodes supplement
AWS D8.7	Automotive spot welding recommendations supplement
AWS D8.8	Automotive arc welding (steel)
AWS D8.9	Automotive spot weld testing
AWS D9.1	Sheet metal welding
AWS D10.10	Heating practices for pipe and tube
AWS D10.11	Root pass welding for pipe
AWS D10.12	Pipe welding (mild steel)
AWS D10.13	Tube brazing (copper)
AWS D10.18	Pipe welding (stainless steel)
AWS D11.2	Welding (cast iron)
AWS D14.1	Industrial mill crane welding
AWS D14.3	Earthmoving & agricultural equipment welding
AWS D14.4	Machinery joint welding
AWS D14.5	Press welding
AWS D14.6	Industrial mill roll surfacing
AWS D15.1	Railroad welding
AWS D15.2	Railroad welding practice supplement
AWS D16.1	Robotic arc welding safety
AWS D16.2	Robotic arc welding system installation
AWS D16.3	Robotic arc welding risk assessment
AWS D16.4	Robotic arc welder operator qualification
AWS D17.1	Aerospace fusion welding
AWS D17.2	Aerospace resistance welding
AWS D18.1	Hygienic tube welding (stainless steel)
AWS D18.2	Stainless steel tube discoloration guide
AWS D18.3	Hygienic equipment welding

Standard Number	**Description**
BS 499-1	Welding terms and symbols. Glossary for welding, brazing and thermal cutting
BS 499-2C	Welding terms and symbols. European arc welding symbols in chart form
BS 2633	Specification for Class I arc welding of ferritic steel pipework for carrying fluids
BS 2971	Specification for class II arc welding of carbon steel pipework for carrying fluids
BS 4515-1	Specification for welding of steel pipelines on land and offshore - Part 1: Carbon and carbon manganese steel pipelines
BS 4515-2	Specification for welding of steel pipelines on land and offshore. Duplex stainless steel pipelines
PD 6705-2	Structural use of steel and aluminium. Recommendations for the execution of steel bridges to BS EN 1090-2
PD 6705-3	Structural use of steel and aluminium. Recommendations for the execution of aluminium structures to BS EN 1090-3

Questions:-

1. What is the role of electrode in welding?
2. Right the AWS code of any types of electrode.
3. What is PD6705-3?

Next Lesson: - weld ability of metals, importance of pre-heating, post –heating and maintenance of inter pass temperature.

Assignment:- Electrodes, types, function of flux, coating factor, sizes of electrode. Coding of electrodes as per BIS, AWS. Moisture pick up of electrode. Storage and baking of electrodes. Special purpose electrode and their application.

Checked by………………………… Instructor………………..