“ WELDER’S HAND BOOK .”

THE CHOICE OF A SUITABLE ELECTRODE

When Choosing an electrode, the first rule is to select one which gives a weld metal quality equal to or better than that of the base metal . Welding Position & type of joint are other factors, which influence the choice of electrode.

General information on the influence of the electrode coating type on welding properties, welding speed and weld metal quality .

Rutile Electrodes giving about 100% weld metal recovery are easy to strike and use and are particularly suitable for short welds in mild steel, for fillet welding,welding sheet Steel and for bridging large joint gaps. The Welds have a fine finish and spatter loses are negligible. The Welding speed is moderate .
Unalloyed Rutil electrodes are not normally recommended for welding steel having a nominal tensile strength exceeding 440 n/mm.sq.
(45 kg/mm. Sq.) Rutile electrodes are relatively insensitive to moisture.

High efficiency rutile electrodes generally gives a higher welding speed, which increases as weld metal recovery increases up to a max . Of About 140 g/min.
All are easy to use,give excellent slag detachability, fine bead appearance and are particularly suitable for welding HORIZONTAL / VERTICAL FILLETS. The weld metal has tensile properties, which are as high as, or some what higher then weld metal from unalloyed basic electrodes but have lower elongation and notch toughness. The evenness of the weld and the smooth transition to the base metal make joints carried out with Rutile electrodes at least as good as unmachined joints made with Basic electrodes.
As regards fatigue strength. Unalloyed Rutile electrodes,irrespective of their efficiency,can be recommended for welding mild steel having a nominal tensile strength 440N/mm. Sq.As regards the tensile strength of the deposit,Rutile electrodes can also be used for welding steel having a higher nominal tensile strength tan 440 N.mm.sq.,but as a general rule only electrodes giving LOW HYDROGEN content weld metal, e.g BASIC,RUTILE- BASIC or ZIRCON- BASIC electrodes should be used for welding these steels.

Acid electrodes without iron powder in the covering are easier to strike than basic electrodes but more difficult to strike and restrike than rutile electrodes. The welding speed is moderate.The weld beads are smooth and shiny. The slag is inflated and easy to remove. The weld metal has a lower yield stress and tensile strength compared with those from rutile electrodes but has higher elongation and Impact toughness. This type of electrodes,which completely dominated the market a few decades ago,has gradually been replaced by RUTILE electrodes for welding in the flat position and BASIC electrodes for position welding. Unalloyed acid electrodes are suitable for welding steels having a nominal tensile strength of up to 440 N/mm.sq.

High efficiency acid electrodes have considerably higher welding speed then the normal electrodes,up to a maximum of about 120g/min.The beads are smooth and shiny. The slag is inflated and easy to remove. High efficiency acid electrodes are particularly suitable for making butt joints and fillet welds in flat position.
The weld metal has the same strength as that from normal acid electrodes,and the application range is therefore similar.

Unalloved basic electrodes have moderate welding speed in the flat position but are faster than other type of electrodes when welding vertically upwards. The reason for this is that basic electrodes can be deposited at a higher current in the vertical position than other types of electrodes. In addition the amount of weld metal deposited per electrode is greater than for other types of electrodes.
The slag is normally not quite as easy to remove as the slag from acid or rutile type of electrodes,but even so it can be classified as easily detachable. The slag from basic electrodes has a lower melting point than that of rutile or acid electrode. The risk of slag inclusions during normal production welding is therefore unusually small when basic type of electrodes are used,even if the slag is not completely remoed between beads during multi-run welding.
The weld metal from basic electrodes has low hydrogen content and usually good toughness even at low temperatures.Basic electrodes are less likely to give either HOT CRACKS or COLD CRACKS compared to other type of electrodes. The superiority of basic electrodes from this point of view appears when welding manganese alloyed structural steels,pressure vessel steels and ship plate having a nominal tensile strengh of 490-530 N/mm.sq. and yield stress of 290-390 N/mm.sq. Higher the hardenability of steel to be welded,the greater the necessity to use basic electrodes, and the greater is the need for low covering moisture content.

Zircon- basic high efficiency electrodes are the fastest of all and are preferably deposited in the flat position. Zircon –basic high efficiency electrodes can be used for welding the same steels as the unalloyed basic electrodes.

Rutile-basic high efficiency electrodes combine the good welding properties of rutile electrodes with high quality weld metal of basic electrodes. They are therefore the best electrodes for making horizontal – vertical fillet welds in high strength steels,where ordinary rutile high efficiency electrode are not permitted. They can be used for welding the same steels as ordinary unalloyed basic electrodes or unalloyed zircon-basic high efficiency electrodes.

Cellulosic electrodes- they are easy to use in all welding positions and are particularly good for vertical and over head welding. Cellulosic electrodes are recommended for all position welding where the mechanical properties of the deposit is of the greatest importance and radiographic requirements are must to meet. Vertical and over head welding require often one size larger electrode in comparison to electrodes with other types of coating. Cellulose electrodes are extremely good for vertical down welding.

Mild steel can be welded without preheating. Higher tensile steel require preheating and higher interpass temperature then when the welding is done with low-hydrogen electrodes.

GUIDE TO ISO CODING

ELECTRODE CLASSIFICATION BY AWS A 5.1

The American Welding Society (AWS) numbering system can tell a welder quite a bit about a specific stick electrode including what application it works best in and how it should be used to maximize performance. With that in mind ,let's take a look at the system and how it works.The prefix "E" designates an arc-welding electrode. The first two digits of a 4-digit number and the first three digits of 5 – digit number indicate tensile strength. For example,E6010 is a 60,000 psi tensile strength electrode while E10018 designates a 100,000 psi tensile strength electrode.

E	60	1	"10"
Electrode	Tensile strength	Position	**Type of Coating and current**

The next to last digit indicates position. The "1" designates an all position electrode, "2" is for flat and horizontal positions only; while "3" indicates an electrode that can be used for flat,horizontal, vertical down and overhead. The last "2" digits taken together indicate the type of coating and the correct polarity or current to use. See chart below:

Digit	Type of coating	Welding Current
10	High cellulose sodium	Dc +
11	High cellulose potassium	Ac or Dc + or Dc -
12	High titania sodium	Ac or Dc-
13	High titania potassium	Ac or Dc +
14	Iron power titania	Ac or Dc- or DC+
15	Low hydrogen sodium	DC+
16	Low hydrogen potassium	AC or DC+
27	Iron powder iron oxide	AC or DC+or DC-
18	Iron powder low hydrogen	AC or DC+
20	High iron oxide	AC or DC+or DC-
22	High iron oxid	AC or DC-
24	Iron powder titania	AC or DC- or DC+
28	Low hydrogen potassium iron powder	AC or DC+

As a welder,there are certain electrodes that you will most likely see and use time and time again as you go about your daily operations. A DC machine produces a smoother arc. DC rated electrodes will only run on a DC welding machin. Electrodes which are rated for AC welding are more forgiving and can also be used with a DC machin. Here are some of the most common electrodes and how they are typcally used:

E 6010
DC only and designed for putting the root bead on the inside of a piece of pipe,this is the most penetrating arc of all. It is top to dig through rust, oil,paint or dirt. It is an all-position electrode that beginning welders usually find extremely difficult,but is loved by pipeline welders world-wide.

E6011
This electrode is used for all - position AC welding or for welding on rusty,dirty,less-than-new metal. It has a deep,penetrating arc and is often the first choice for repair or maintenance work when DC is unavailable.

E 6013
This all-position,AC electrode is used for welding clean,new sheet metal. Its soft arc has minimal spatter,moderate penetration and an easy-to-clean slag.

E 7018
A low- hydrogen,usually DC,all-position electrode used when quality is an issue or for hard-to-weld metals. It has the capability of producing more uniform weld metal,which has better impact properties at temperatures below zero deg C.

E7024
Typically used to make a large weld down hand with AC in plate that is at least ¼" thick, but more commonly used for plate that is ½" and up.

Other electrodes
Although not nearyly as common,an electrode may have additional numbers after it such as E 8018-B2H4R. In this case,the “B2” indicates chemical composition of the weld metal deposit. The “H4” is the diffusible hydrogen designator,which indicates the maximum diffusible hydrogen level obtained with the product. And “R” stands for the moisture resistant designator to indicate the electrode’s ability to meet specific low moisture pickup limits under controlled humidification tests .

WELDING POSITION IN ACCORDANCE WITH ASME IX/BS EN ISO 6974 :

BRITISH/ EUROPEAN MMA ELECTRODE STANDARDS .

OLD STANDARDS	DESCRIPTION.	NEW STANDARDS.
BS 639.	C/Mn.STEEL,COVERED ELECTRODES.	BS EN 499.
BS.2493.	LOW ALLOY STEEL ELECTRODES	BS EN 757 (High strength low alloy) BS EN 1599 (creep resisting steel)
BS 2926.	STAINLESS STEEL ELECTRODES.	BS EN 1600 .

SELECTING THE CORRECT CURRENT FOR THE JOB.

Before commencing to weld always be sure that the current is correct for the job in hand. The recommended current range for each electrode has already been specified in product literature. However, different applications require slight variation within the recommended current range . As shown in the following table.

WELDING POSITION.	PLATE THICKNESS (Relative to electrode dia.)		
	THIN.	MEDIUM.	THICK.
HORIZONTAL VERTICAL. (Fillet, etc)	LOW .	MEDIUM.	HIGH.
FLAT (Butt & Tilted fillets.	MEDIUM.	HIGH.	HIGH.
OVERHEAD.	LOW.	MEDIUM.	MEDIUM.
VERTICAL DOWN.	LOW.	MEDIUM.	MEDIUM.
VERTICAL UP.	-----	VERY LOW.	LOW.
INCLINED .	-----	VERY LOW.	LOW.

In addition make minor adjustment in the current setting for size of run. Long, thin runs require higher currents whereas short, thick runs require lower currents.

General guide to pre heating

High carbon steels and low alloy steels may require preheating of the joint area to avoid weld metal cracking or ‘ under bead cracking’ . The following table should serve as a guide.

Group	Pre Heating.
Group –I ----- Straight Carbon Steel Under 0.25% C or low alloy Steel Under 0.12% C.	In general, not necessary,except with carbon contents on the higher side of this range and with heavy plate and rigid joints. Approximate PREHEAT TEMPERATURE-100-150 deg .C.
Group-II--- straight Carbon Steel 0.25-0.35% C or low alloy steel 0.12-0.25%C.	Preferable,though not usually necessary in thin sections. Approximate PREHEAT TEMPERATURE --- 100-200 deg.C.
GROUP –III--- Straight carbon steel 0.35-0.45%C or Low Alloy Steel 0.20-0.30%C.	Preferable and in most cases, necessary. Approximate PREHEAT TEMPERATURE 150-250 deg.C.
GROUP-IV--- Straight Carbon Steel Above 0.45% C or Low Alloy Steel Above 0.30% C or Alloy Steel above About 3% Toll Alloy Content.	NECESSARY --- 200-350 deg.C.

SCHEDULE OF PREHEATING TEMPERATURE AND ELECTRODES

STEEL.	THICKNESS	MINIMUM PREHEAT TEMPERATURE.

		Deg.C. LH Electrode Rutile Electrode.
Mild Steel 52 kg/mm sq.	Up to 20 mm.	Nil. NiL.
	20mm-50mm	Nil. 100 deg C.
High tensile steel 54-62 kg/mm sq.	Up to 20 mm.	Nil. 100 deg C.
	20mm-50mm	!00 deg C. Should not be used.
TI Steel.	Up to 20 mm.	120 deg C. Should not be used.
	Higher thickness	Consult the manufacturer.
½ Mo Steel	Up to 20 mm.	Nil. 100 deg.C.
	20mm-50mm	100 deg C. Should not be used.
1Cr- ½ Mo Steel	Up to 20 mm.	100 deg C. 100 deg C.
	20 mm-50 mm.	100 deg C. Should not be used.
2 ¼ Cr.-1Mo Steel.	Up to 20 mm.	200 deg C. Should not be used. 3
5Cr- ½ Mo Steel	Up to 50 mm.	300 deg C. Should not be used.

WELD DEFECTS

POROSITY
Can be seen on the surface or may be hidden inside the weld. Caused by damped electrodes,rusty or dirty plates. Higher sulpher in the plates,or

sluggishness of the weld metal. If the weld is sluggish increase the current and weave the electrode briskly.

SLAG INCLUSION

Can be on surface or hidden. Caused by the dirty faces of the joint,improper arrangement of the passes,inadequate cleaning after each pass. Sometimes due to bad electrode performance. Also caused by using too large an electrode in the narrow groove.

LACK OF FUSION

Caused by incorrect joint preparation and fit-up,use of too large an electrode or too small an electrode in relation to the joint size,improper arrangement of passes,too low a current for given size of electrode.

UNDERCUTTING

Caused by using too high current and too fast welding speed. Also due to improper angle of the electrode.

OVERLAPPING

Caused by using too low current and too slow welding speed. Also due to improper angle of the electrode.

CRACKS

Caused by the following- along or in combination . the remedies suggested are :

- Weld metal is not ductile enough, it may be too low in manganese or too high in carbon. Change over to a better electrode.

- Base metal is high in carbon or sulphur or hardening elements like Cr,V,Ni,ect. Change the base metal or use low-hydrogen electrode and pre heating is necessary .

- Base metal is too thick or the assembly is under very heavy restraint. Use preheat and correct welding sequence.
- Electrodes are very damp. Dry the electrodes as per recommendations.
- Bad fit- up resulting in lack of fusion at the root. Improve fit-up and ensure good fusion at the root.
- In high carbon steels and alloy steels,specially when the sections are thick, “under cracks” are found at the junction between weld metal and the base metal. They are invisible and open out to the surface after sometime. They can be avoided by using low –hydrogen

electrodes freshly dried in an oven, and preheating the joint area adequately.

BUTT WELDS

The main defect is lack of root penetration which is caused because the root is not gouged out adequately before welding from the second side.

FILLET WELDING

Main defects are lack of root penetration,unequal leg lengths, too much convexity and under cutting at the toes. Lack of root penetration can be avoided by using a bigger diameter electrode with adequate current. Wrong electrode angle causes unequal leg lengths. To avoid undercut do not use too high current and too fast welding.

WELDING SEQUENCE AND CONTROL OF DISTORTION

Correct welding sequence is necessary to avoid weld metal cracking and distortion. For controlling distortion in a single “v” butt joint,you can preincline the plates or clamp the joint assembly very strongly or correct the distortion in a press or by heating and hammering. For double “V” butt joint ,you can weld alternatively on each side. For making very long butt joint,you can weld alternatively on each side. For making very long butt joints,the length is divided into two equal parts with a center line. Then two welders start at the center and go downwards. Though the general direction of welding is away from the center line,each individual weld is made towards the center line. This is called “ BACK –STEP” welding. In welding a circular patch the circumference is divided into eight segments and two opposite segments are welded by two welders simultaneously.

TO AVOID DISTORTION TAKE THE FOLLOWING STEPS

- Use minimum weld metal. Avoid over welding .
- Use correct fit-up. Avoid wide bevels and wide root gaps.
- Use correct sequence.
- Deposit the weld metal in minimum number of passes. In other words use largest size of electrode.
- Ensure that parts to be welded have accurate dimensions and fit each other easily. If parts have to be forcibly brought together they cause distortion and some times weld metal cracking.
- Divide complicated work into sub assemblies and weld each of them separately.
- Allow for weld shrinkage. Otherwise the dimensions of the finished product will not be accurate. Design departments must take care of shrinkage allowance.

SAFETY IN ARC WELDING

The welding arc is a source of intense energy. It emits harmful rays linke ultra violet rays,infra-red rays, and fumes which may cause unpleasantness to the welder. Hot metal,slag and spatter often can be hazardous to the operator. Adequate precautions are therefore required to safe quard form :

- Electric shock
- Radiation from the arc.
- Scattering of hot particles and globules of metal.
- Flying pieces of sharp slag when being chipped.
- Heat and fume.

The welder should,as a protective measure,observe the instructions given below

- Wear sufficient clothing of a kind that is closely woven to protect all parts of his body from rays,scattered hot metal,etc.

- Protect eyes and faces using helmets,shields or goggles fitted with the right type of filter glasses.
- Risk of shock can be reduced by insulating himself from the ground or nearby metal objects,especially when changing electrodes. Dry leather gloves and rubber- soled shoes should be worn .
- The electrode holder should be sufficiently insulated.
- The welding equipment must be safely earthed. A hook or an insulated board should be used for hanging up the electrode holder when not in use.
- The welding shop should be adequately ventilated. When welding in confined spaces,forced ventilation must be provided.
- Combustible materials should never be stored near the welding booth nor should they be used to support the work.
- Pipelines,tanks or portable containers should never be welded without first making sure that they are free from an explosive mixture of vapors.

EVALUATE CODE SPECIFICATIONS

Codes, specifications,and contract documents provide fabrication requirements that must be maintained when applied to welded construction . However, some provisions are perceived as “requirements” when they are not applicable,or when alternatives are permitted. Under these conditions,it is prudent to carefully evaluate such “requirements” and, when appropriate,consider alternatives that may provide fabrications of equal or better quality, and at reduced cost.

Consider, for example, the requirements as they relate to complete joint penetration (CJP) groove welds made in accordance with the American Welding Society Structural Welding Code-Steel (AWS D1.1:2000). A review of the prequalified joint details in AWS D1.1,Figure 2.4 reveals that all CJP groove welds (with one exception which will be discussed below) utilize either single- sided joints with steel backing,or double – sided joints that involve back gouging (see Figures 1 and 2). Either option is permitted, and when properly made,both should result in a weld throat that is equivalent to the thickness of the thinner base metal joint.

The single exception to this is the B-L1-S detail(see Figure 3),which is limited to a maximum thickness of 3/8 in (10mm). This detail relies on the penetration of the submerged arc welding process to achieve a CJP groove weld.

It would be easy to conclude that AWS D1.1 requires either (a) steel backing for one-sided joints, or (b) double –sided joints that use back gouging. However, this conclusion would be incorrect,and a careful evaluation of code “requirements” with respect to this criterion will reveal that the code permits alternatives.

The key principle that provides understanding in this particular instance is the difference between pre-qualified Welding Procedure Specifications (WPSs) and those that are qualified by test. in order for a WPS to be pre-qualified, it must comply with all the criteria of chapter 3 in the AWS D1.1 Structural Welding Code. However, it is also possible to qualify WPSs by test in conformance with AWS D1.1,Chapter 4 –Qualification. Such qualification testing could thereby permit the use of other materials for backing, including ceramic,glass tape,copper and iron powder (see AWS D1.1,section 5.10).

Qualification testing could similarly permit the use of double – sided joints without back gouging. This is specifically addressed in AWS D1.1, Table 4.5- PQR Essential Variable Changes Requiring Re-qualification for SMAW,SAW,GMAW,FCAW,and GTAW, “ Item 35.This provision states that” the omission,but not inclusion, of backing or back gougine” would require qualification of the WPS.

Case Study

For many years, a fabricator had made CJP groove welds in T-joints for offshore applications, using double- sided joints with back gougin, consistent with the pre-qualified AWS D1.1 joint detail TC-U5-GF (see Figure 4). Rather than incorrectly assuming that back gouging of two sided CJP groove welds was a “requirement,” this fabricator took advantage of the D1.1 code alternative which
Permitted WPS qualification without the use of back gouging.

The alternative approach replaced the back gouging operation with a unique root pass procedure that ensured a CJP groove weld. The overall joint was a tee,composed of two 3 in (75mm) steel members, and was prepared with a double bevel groove preparation,using a 50 degree included angle,no root opening and no root face. Two pulsed GMAW arcs, operating from opposite sides of the web,simultaneously made the root passes. Longitudinal spacing for the opposed arcs was approximately ½ in (12mm). Figure 4 shows the root passes,with complete penetration.figure 5 shows the completed joint that was filled with pulsed GMAW as well.

Such techniques necessitated WPS qualification testing,but the potential cost savings greatly outweighed the expense of the WPS qualification testing.

Conclusions

Reevaluation of “requirements” such as backing or back gouging for AWS D1.1 CJP groove welds may permit the use of cost- effective alternatives. Once a WPS is qualified, it than may be submitted to the Engineer for approval ,consisten with AWS D1.1, section 4.1.1.

In other situations, Code provisions can be waived and alternatives permitted when approved by the Engineer. For example,AWS D1.1,section 6.8 permits the Engineer to use alternative criteria for specific applications. Approving alternatives should not be casually approached, and the Engineer is encouraged to rely upon prior experienced engineering judgment, in addition to analytical or experimental data. However, alternatives can be approved in this manner,permitting viable alternatives.

In the preceding case study,the cost savings achieved were impressive. Equally important,overall quality is expected to be enhanced since reliance is made upon a system that includes careful control of the welding procedures for the root pass,rather than on back gouging operations that are inherently subject to variations in operator skill. As is frequently the case,this cost – saving effort also improved quality.

Fig.1 Single – sided CJP weld with steel backing .

Fig.2 Back - gouged double- sided CJP weld.

Fig.3 Pre – qualified AWS D1.1 joint detail B-L1-S (used with permission of the American Welding Society.

FREQUENTLY ASKED QUESTIONS.

1. The E7018 welding rods I've been buying are now marked E7018 H4R. what does the H4R mean? Are these rods different than the E7018 rods I've used before?

H4R is an optional supplementary designator,as defined in AWS A5.1-91 (specification for shielded metal arc welding electrodes). Basically,The number after the "H" tells you the hydrogen level and the "R" means it's moisture resistant.

"H4" identifies electrodes meeting the requirements of 4ml average diffusible hydrogen content in 100g of deposited weld metal when tested in the "as – received" condition.
"R" identifies electrodes passing the absorbed moisture test after exposure to an environment of 80ºF(26.7ºC) and 80% relative humidity for a period of not less than 9 hours. In the "as-received" condition.

2-why is hydrogen a concern in welding?

Hydrogen contributes to delayed weld and/or heat affected zone cracking. Hydrogen combined with high residual stresses and crack-sensitive steel may result in cracking hours or days after the welding has been completed.

High strenght steels, think sections,and heavily restrained parts are more susceptible to hydrogen cracking. On these materials,we recommend using a low hydrogen process and consumable,and following proper preheat,inter-pass,and post – heat procedures. Also, it is important to keep the weld joint free of oil,rust,paint,and moisture as they are sources of hydrogen.

3- what consumables are better for welding over rusty,dirty steel?

Steel should be cleand of any oil,grease,paint,and rust before using any arc welding process. However, if complete cleaning cannot be performed,consumables that form a slag, have deeper penetration,are slower freezing,or have higher Silicon and manganese are recommended for dirty steels. These consumables include:

4-what precaution should I take when welding T-1 steels?

T-1 is a quenched and tempered steel. Welding quenched & tempered steels may be difficult due its high strength and hardenability. The base steel around the weld is rapidly being heated and cooled during welding, resulting in a heat affected zone (HAZ) with high hardenss. Hydrogen in the weld metal may diffuse into HAZ and cause hydrogen embrittlement, resulting in delayed under- bead or toe cracking outside of the weld. To minimize heat affected zone cracking:

1.use a low hydrogen consumable,like a H4 or –H2.
2.preheat. This slows the cooling rate. Note that excessive preheat may anneal the base material.
3.slow cool. More time at elevated temperatures allows the dissolved hydrogen to escape.
4.Peen the weld beads to minimize residual weld stresses.
5.Usd the lowest strength filler metal meeting design requirements. If making fillet welds,the weld can be oversized to give the specified strength.
6.minimize weld restraint .

5- what are you recommendations for welding AR400 plate?

AR400 is a quench and tempered steel and may be difficult to weld due its high strength and hardenability. The base steel around the weld rapidly heats and cools during welding, resulting in a heat affected zone (HAZ) with high hardness. Any hydrogen in the weld metal may diffuse into HAZ and may cause hydrogen embrittlement, resulting in delayed under – bead or toe cracks outside of the weld. To minimize heat affected zone craking :

1. Use a low hydrogen consumable with an – H4 or – H2 designation .
2. Preheat to slow the cooling rate. Note that excessive preheat may anneal the base material.
3. Slow cool. More time at elevated temperatures allows the dissolved hydrogen to escape.
4. Peen the weld beads to minimize residual weld stresses.

6- why are the charpy impact values from my test welds lower than that printed on test certificate of conformance ?

the test results on Certificate of Conformance were obtained from welding an AWS filler metal test plate. Any change in weldeing procedure will affect Charpy impact values. Below are common practices for welding test plates when Charpy impact specimens are required:

1-controlled heat input
2-controlled preheat and inter – pass temperature
3-Even number of passes per layer

build- up cap pass to maximum allowed in specification

7- why is preheat sometimes required before welding?

Preheating the steel to be welded slows the cooling rate in the weld area. This may be necessary to avoid cracking of the weld metal or heat affected zone. The need for preheat increases with steel thickness, weld restraint,the carbon/alloy content of the steel,and the diffusible hydrogen of the weld metal. Preheat is commonly applied with fuel gas torches or electrical resistance heaters.

8- How should preheat be measured?

AWS D1.1 Structural Steel welding Code, section 5.6 states:
Preheat and all subsequent minimum inter- pass temperatures shall be maintained during the welding operation for a distance at least equal to the thickness of the thickest welded part, but not less than 3 in. [75 mm] in all directions from the point of welding.
In general,when preheat is specified, the entire part should be thoroughly heated so the minimum temperature found anywhere on that part will meet or exceed the specified preheat temperature.

9- what is inter –pass temperature ?

inter-pass temperature refers to the temperature of the steel just prior to the depositing of an additional weld pass. It is identical to preheat, except that preheating is performed prior to any welding.
When a minimum inter-pass temperature is specified,welding should not be performed when the base plate is below this temperature. The steel must be heated back up before welding continues.

A mximum inter- pass temperature may be specified to prevent deterioration of the weld metal and heat affected zone properties. In this case,the steel must be below this temperature before welding continues.

10 – Do I need an oven to stor low hydrogen electeodes ?

All low – hydrogen consumables must be dry to perform propely. Unopened lincoln hermetically sealed containers provide excellent protection in good storage conditions. Once cans are opened, they should be stored in a cabinet at 250º - 300ºF (121º 149ºc).

When the electrodes are exposed to the air, they will pickup moisture and should be re- dried. Electrodes exposed to the air for less than 1 week with no direct contact with water should be re-dried as follows:

E 7018: 1 hour at 650º -750º F
E 8018, E9018, E10018,E11018: 1 hour at 700º-800º F

If the electrodes come in direct contact with water or have been exposed to high humidity, they should be pre-dried for 1-2 hours at 180º- 220ºF first before following the above re- drying procedure. standard EXX18 electrodes should be supplied to welders twice per shift. Low hydrogen electrodes with the suffix “MR” have a moisture resistant coating and may be left out up to 9 hours or as specified by code requirements.

Mechanical properties. Type of coating.

Electrode designation	Tensil strength N/mm.sq.	Minimum elongation on L = 5d (%)	Temperature for minimum impact alue of 28 J.(C)				
E 430							
E431							
E432							

E 51 3 B 160 2 0 H.

Low hvdrogen electrode

% metal recovery for not less than 110% recovery.

Current condition.

Symbol	Dc polarity recommended	Ac current minimum ocv.
0	+	50
1	+ or -	50
2	-	50
3	+	50
4	+ or-	70
5	-	70
6	+	70
7	+ or -	90
8	-	90
9	+	90

Welding position.

1 all position
2 all position except vertical down
3 flat bytt weld,flat fillet weld,
4 flat butt weld, flat fillet weld.
5 as 3 and recommended for vertical downward.