GENERAL DESCRIPTION

METAL JOINING METHODS

WELDING

"Welding is a process of joining two or more pieces of the same or dissimilar materials to achieve complete coalescence. This is the only method of developing monolithic structures and it is often accomplished by the use of heat and/or pressure.

ADVANTAGES OF WELDING

Welding is superior to other metal joining methods because it:

- Is a permanent pressure tight joint
- Occupies less space
- Gives more economy of material
- Has less weight
- Withstands high temperature and pressure equal to joined material
- Can be done quickly
- Gives no color change to joints.

It is the strongest joint and any type of metal of any thickness can be joined.

DIFFERENT METHODS OF WELDING

- Fusion method without pressure/ with pressure
- Non-fusion method

Fusion welding without pressure

The joint made is permanent. The common heating sources are:

- Arc welding
- Gas welding
- Chemical reaction (Thermit welding)

Pressure welding

❖ Heat source may be blacksmith forge (forge welding) or electric resistance (resistance welding) or friction

NON-FUSION WELDING

This is a method in which similar or dissimilar metals are joined together without melting the edges of the base metal by using a low melting point filler rod but without the application of pressure.

Electric welding processes can be classified as:

- Electric arc welding
- Electric resistance welding
- Laser welding
- Electron beam welding
- Induction welding

Electric arc welding can be further classified as:

- Metallic arc welding
- Carbon arc welding
- Atomic hydrogen arc welding
- Inert gas arc welding/ TIG welding
- CO_2 gas arc welding
- Flux cored arc welding
- Submerged arc welding
- Electro-slag welding
- Plasma arc welding

Electric resistance welding can be further classified as:

- Spot welding
- Seam welding
- Butt welding
- Flash butt welding
- Projection welding

Gas welding processes can be classified as:

- Oxy-acetylene gas welding
- Oxy-hydrogen gas welding
- Oxy-coal gas welding
- Oxy-liquefied petroleum gas welding
- Air acetylene gas welding

COMMON METALS AND ALLOYS

Metals may be ferrous, non-ferrous metals and alloys.

Ferrous metals are those which have iron as their base. They include iron and its alloys such as steel, cast iron and alloy steels such as stainless steel etc.

Non-ferrous metals do not contain iron as base. They include copper, aluminium, zinc, tin etc and non-ferrous alloys.

Alloys

If two or more metals are chemically combined they form an alloy e.g. iron, chromium nickel and carbon form an alloy called chromium nickel steel (stainless), manganese, iron and carbon form an alloy called manganese steel, copper and zinc form an alloy called brass, copper and tin form an alloy called bronze, lead and tin form an alloy called soft solder.

PROPERTIES OF METALS

Properties of metals can be classified mainly into:

- Chemical properties
- Physical properties
- Mechanical properties

- **Chemical properties :-** are those which involve chemical effect such as:
- Corrosion
- Oxidation
- Reduction

Corrosion will spoil the metal surface due to the effect of various elements in the atmosphere and water.

Oxidation is the formation of metal oxides which occur when oxygen combines with metals.

Reduction refers to the removal of oxygen from the surrounding molten puddle to reduce the effect of atmospheric contamination.

Physical properties are those, which affect metals when they are subjected to heat generated by welding such as:

- melting point
- thermal conductivity
- thermal expansion
- grain growth

Melting point is the degree of temperature, when a solid metal changes into liquid. Melting points of some metals are given below:

1.	Mild steel	1500 to 1530°C
2.	Cast iron	1150°C
3.	Copper	1083°C
4.	Aluminium	659°C
5.	Brass and bronze	950°C
6.	Zinc	419°C
7.	Tin	232°C
8.	Lead	327°C
9.	Nickel	1452°C
10.	Soft solder	190°C

Mechanical Properties

Mechanical properties are those which determine the behavior of metals under applied load such as:

- Tensile strength
- Ductility
- Hardness
- Toughness
- Brittleness

EFFECT OF WELDING HEAT ON THE PROPERTIES OF METALS

During welding the properties of the weld metal may be affected.

- Important alloying elements may be destroyed.
- Brittle, hard or cracked welds may be produced.
- There may be reduction in the corrosion resistance properties of the welds.
- Main properties of the base metal and weld metal will get affected

EFFECT OF ATMOSPHERIC AIR ON WELDING

The atmospheric air is a gaseous mixture of mainly nitrogen and oxygen, with some other gases like hydrogen, etc. in small percentages.

Since the atmospheric air contains 21% of oxygen, whenever a red hot or molten iron comes in contact with atmospheric air the metal gets oxidized.

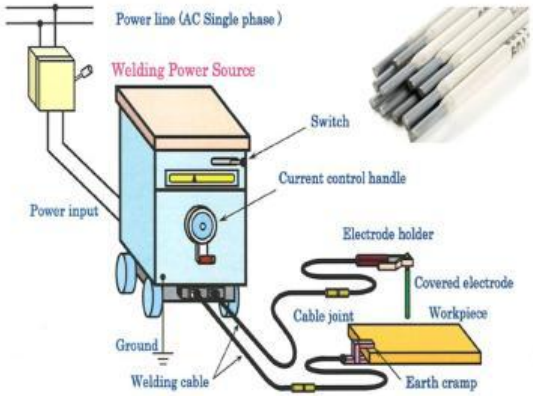
Oxygen contamination i.e. oxidation will reduce the mechanical properties of the weld metal. In other words the tensile strength, toughness and ductility of the weld decrease with increased oxygen contamination.

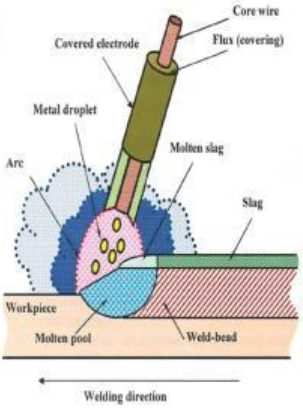
ELECTRIC WELDING PROCESSES

TYPES OF ELECTRIC WELDING

❖ ELECTRIC ARC WELDING

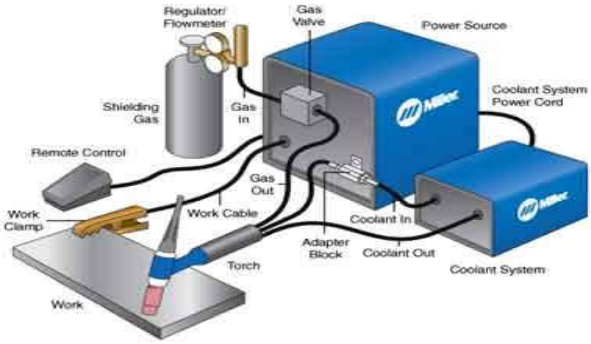
Electric arc is formed when both the terminals of an electric circuit are brought together and then separated by a small gap. When high current passes through an air gap from one conductor to another, it produces very intense and concentrated heat in the form of a spark. The temperature of this spark (or arc) is app. 3600°C, which can melt and fuse the metal very quickly to produce a homogeneous weld. The types of electric arc welding are as follows.





❖ Tungsten Inert Gas arc welding (TIG)

In this process the arc is formed between the tungsten electrodes (non-consumable) and the welding job in an atmosphere of an inert gas (argon or helium). A separate filler rod is used to add the filler metal. This process is also called gas tungsten arc welding (GTAW) process.

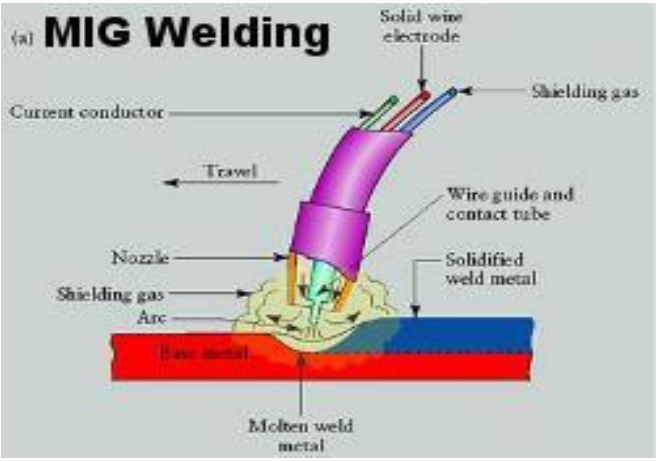


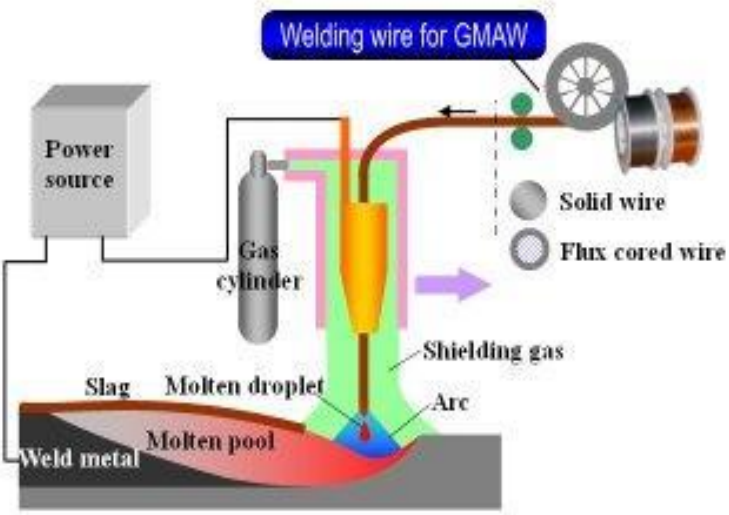
METAL INERT GAS /METAL ACTIVE GAS WELDING

In this process the arc is formed between a continuous, automatically fed, metallic consumable electrode and welding job in an atmosphere of inert gas, and hence this is called metal inert gas arc welding (MIG) process.

When the inert gas is replaced by **carbon dioxide** then it is called **CO_2 arc** welding or **Metal Active Gas (MAG)** arc welding.

The common name for this process is Gas Metal Arc Welding **(GMAW).**

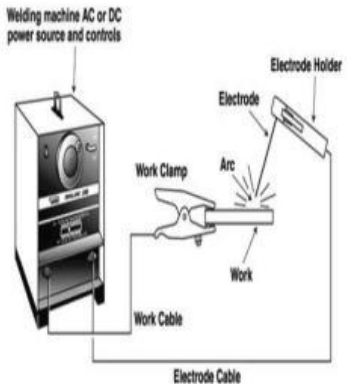




SALIENT FEATURES:-

- It is an arc welding process in which the heat required for the welding comes from an electric arc.
- The electric arc develops when electricity jumps across an air gap (ionization of air) between the end of the metallic electrode and the welding job surface.
- The metallic electrode is generally coated with a flux which is consumable.
- The arc created due to the ionization of air between the electrode tip and the base metal generates an intense arc heat having a temperature between 3600°C-4000°C.
- The welding current is provided by an AC or DC machine.
- The intense heat of the arc melts a small portion (molten pool) on the job directly under the arc and at the end of the electrode instantaneously.
- The melted electrode fuses into the molten pool of the welding job and produces a homogeneous weld on cooling.

➢ **Shielded Metal Arc Welding (SMAW)**.

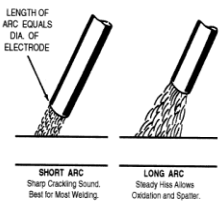


- The flux coating on the electrode also melts and provides a gaseous shield around the arc which protects the molten metal from atmospheric contamination. Hence this is called **Shielded Metal Arc Welding (SMAW)**.
- The welding speed and feed of the electrode is controlled manually by the welder himself. So it is also called **Manual Metal Arc Welding (MMAW)**.
- When the weld metal solidifies, the slag (of flux coating) gets deposited on its surface as it is lighter than the metal and the weld metal is allowed to cool gradually and slowly.

ARC LENGTH

It is the straight distance between the electrode tip and the job surface when the arc is formed. There are three types of arc lengths:

- Medium or normal
- Long
- Short

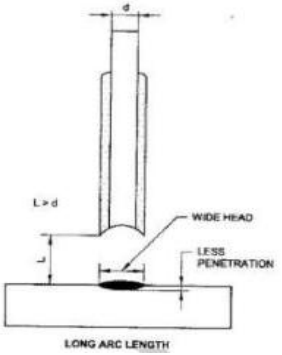


LONG ARC

If the distance between the tip of the electrode and the base metal is more than the diameter of the core wire it is called a long arc. It makes a humming sound causing:

- unstable arc
- oxidation of weld metal
- poor fusion and penetration

It is used in plug and slot welding, for restarting the arc and while withdrawing the electrode at the end of a bead after filling the crater. Generally long arc is to be avoided as it will give a defective weld.



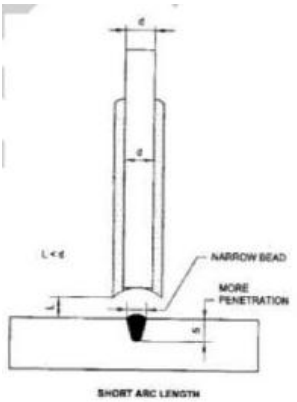
SHORT ARC

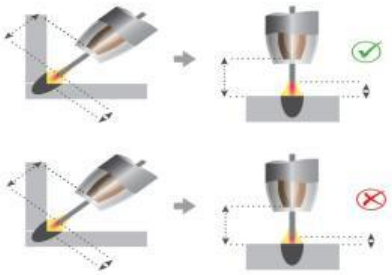
If the distance between the tip of the electrode and the base metal is less than the diameter of the core wire, it is called a short arc. It makes a popping sound causing:

- The electrode melting fastly and trying to freeze with the job
- Higher metal with narrow width bead
- Less spatters
- More fusion and penetration.

It is used for root runs to get good root penetration, for positional welding and while using a heavy coated electrode, low hydrogen, iron, powder and deep penetration electrode.

- Poor control of molten metal
- More spatters, indicating wastage of electrode metal.





SAFETY IN MANUAL METAL ARC WELDING

During arc welding the welder is exposed to hazards such as injury due to harmful rays (ultra violet and infra red rays) of the arc, burns due to excessive heat from the arc and contact with hot jobs, electric shock, toxic fumes, flying hot spatters, slag particles and objects falling on the feet.

The following safety apparels and accessories are used to protect the welder and other persons working near the welding area from the above mentioned hazards.

1. Safety apparels

a. Leather apron
b. Leather gloves
c. Leather cape with sleeves
d. Industrial safety shoes

2. Hand screen

a. Adjustable helmet
b. Portable fire proof canvas screens

3. Chipping/ grinding goggles Respirator and exhaust ducting

RECOMMENDATION OF FILTER GLASSES FOR MANUAL METAL ARC WELDING.

Shade No. of coloured glass	Range of welding current in amperes
8-9	Upto 100
10-12	100 to 250
12-14	Above 250

Plain goggles are used to protect the eyes while **chipping** the slag or **grinding** the job. It is made of Bakelite frame fitted with clear glasses and an elastic band to hold it securely on the operators head. It is designed for comfortable fit, proper ventilation and full protection from all sides.

3. SAFETY APPARELS

The leather apron, gloves, cape with sleeves and leg guard are used to protect the body, hands, arms, neck and chest of the welder from the heat radiation and hot spatters from the arc and also from the hot slag particles flying from the weld joint during chipping off the solidified slag.

ARC WELDING ACCESSORIES

Some very important items used by a welder with an arc welding machine during the welding operation, are called arc welding accessories.

Electrode Welding cables/ leads -holder

Earth Clamp

MATERIAL PREPARATION METHOD

POLARITY IN DC ARC WELDING

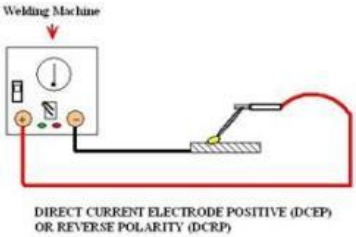
Importance of polarity in welding

In DC welding 2/3 of the heat liberated from the positive end and 1/3 from the negative end. To have this advantage of unequal heat distribution in the electrode and base metal, the polarity is an important factor for successful welding.

In AC, the polarity cannot be utilized as the power source changes its poles frequently.

Kinds of polarity are two:

- Straight polarity or electrode negative (DCEN).
- Reverse polarity or electrode positive (DCEP).

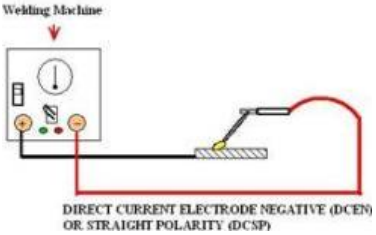


STRAIGHT POLARITY (DCEN)

In straight polarity the electrode is connected to the negative and the work to the positive terminal of the power source.

REVERSE POLARITY (DCEP)

In reverse polarity the electrode is connected to the positive and the work to the negative terminal of the power source.



Reverse polarity is used for:

DC is preferred to AC for hard facing and stainless steel welding.

Choice of the polarity also depends on the instruction of the electrode manufacturers.

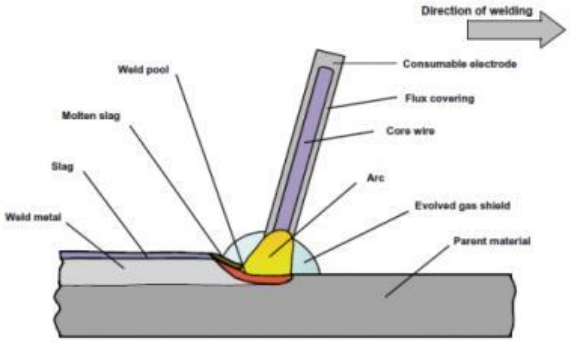
In order to get the best results, it is essential to attach the electrode with the correct terminal of the welding machine.

FUNCTIONS OF AN ELECTRODE IN SHIELDED METAL ARC WELDING (SMAW)

There are two main functions of an electrode in shielded metal arc welding:

- The core wire conducts the electric current from the electrode holder to the base metal through the arc.
- It deposits weld metal across the arc onto the base metal.

The flux covering melts at a slower rate than the metal core and a cup is formed at the tip of the electrode which helps to direct the molten metal to the required spot.



IDENTIFICATION OF ELECTRODES

For easy identification and selection of a suitable arc welding electrode for welding mild steel plates, the electrodes are coded by Bureau of Indian Standards **(B.I.S)**. According to the B.I.S., the electrodes to be used for welding mild steel for training a beginner is coded as ER4211.

The classification for the electrode ER4211 is given below for easy understanding:

E = Flux coated or covered electrode

R = Type of flux covering (Rutile)

4 = Strength of the joint (UTS = 410-510 N/nm^2 and YS = 330N/nm^2 min.

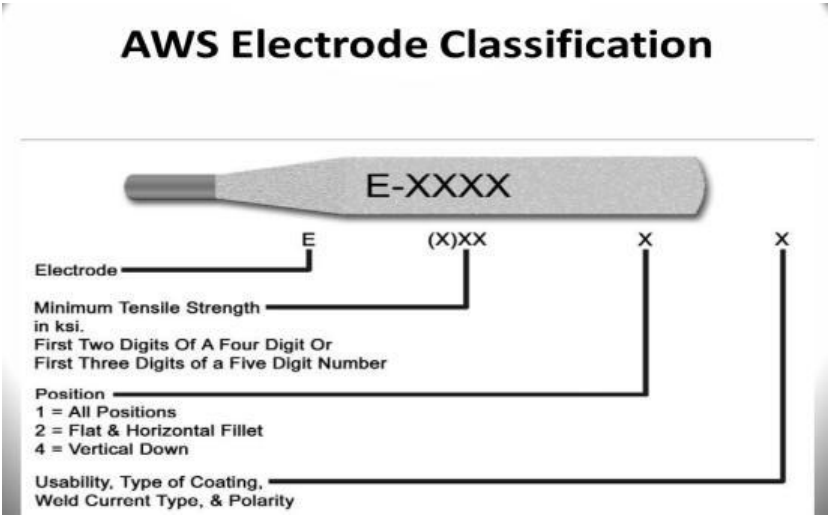
2 = Elongation and impact properties of the weld (Elongation = 22% min. and impact = 47 J min. at 0°C)

1 = Welding position (all position) welding can be done in all positions

1 = Welding current and voltage conditions. This means that for DC welding, the electrode can be connected to the +ve or –ve terminal. For AC welding, the open circuit voltage should be 50 volts.

FLUX COATED ELECTRODES

1.	Light coated	1.	Non-ferrous.
2.	Medium coated	2.	Cast iron.
3.	Heavy coated electrodes	3.	Alloy steel and mild steel electrod



ELECTRODE CODING

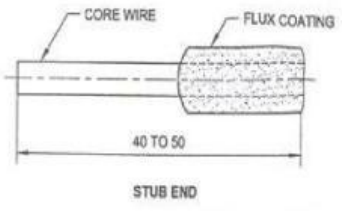
At present three methods are for electrode coding:

- B.S. or BEAMA (British standard or British Electrical and Allied Manufacturing Association) method.
- A.W.S. or A.S.T.M. (American Welding Society or American Society of Testing Material) method.
- I.S. (Indian Standard) method.

USAGE AND STORAGE OF ELECTRODES

Usage and storage of electrodes

- Electrodes are costly, therefore, use and consume every bit of them.
- Do not discard STUB ENDS more than 30-40 mm length.
- Electrode coating can pick up moisture if exposed to atmosphere.



- Store and keep the electrodes (air tight) in a dry place.
- Heat the moisture affected/ prone electrodes in an electrode drying oven at 110-150°C for one hour before using.

WELDING ELECTRODE OVEN

HAND OVEN

Remember a moisture affected electrode:

- has rusty stub end
- has white powder appearance in coating
- produces porous weld.

Storage of electrodes:

- The efficiency of an electrode is affected if the covering becomes damp.
- Keep electrodes in unopened packets in a dry store.
- Place packages on a duckboard or pallet, not directly on the floor.
- Store so that air can circulate around and through the stack.

- Do not allow packages to be in contact with walls or other wet surfaces.

- The temperature of the store should be about 5°C higher than the outside shade temperature to prevent condensation of moisture.

- Free air circulation in the store is as important as heating. Avoid wide fluctuations in the store temperature.

- Where electrodes cannot be stored in ideal conditions place a moisture absorbent material (e.g. silica gel) inside each storage container.

DRYING ELECTRODES: Water in electrode covering is a potential source of hydrogen in the deposited metal and thus may cause.

- Porosity in the weld
- Cracking in the weld

INDICATIONS OF ELECTRODES AFFECTED BY MOISTURE ARE:

- White layer on covering
- Swelling of covering during welding

- Disintegration of covering during welding
- Excessive spatter
- Excessive rusting of the core wire.

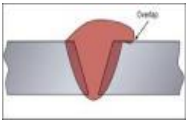
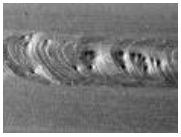
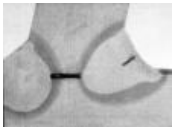
Electrode affected by moisture may be dried before use by putting them in a controlled drying oven for approximately one hour at a temperature around 110-150°C. This should not be done without reference to the conditions laid down by the manufacturer. It is important that hydrogen controlled electrodes are stored in dry, heated conditions at all times.

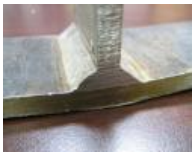
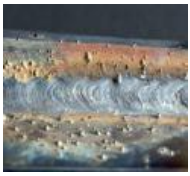
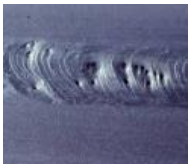
ISR CLASS	USE	IS/AWS SPEC.	IS/AWS CODE
A-1	Steel sheet joining & GR. FE 330, repairing welding of cast steel GR.200-400W & IS: 2062-99, GR A.IS: 1875-92 class 1 & 1A or similar	IS: 814-91	ER 4112 medium coated
A-2	Fabrication of steel bridges the weld deposit shall be of radiographic quality IS:2062-99 GR.B.IS: 1875-92 class 1 & 1A or similar	IS: 814-91	ER 4112X medium coated
A-3	Highly dynamic application made of steel IS:2062-99 GR.C. & low temperature impact property. The weld deposit shall be of radiographic quality	IS: 814-91	EB 5326H2X medium coated
A-4	Highly dynamic application made of steel IS:2062-99 GR. C & low temperature Impact property. The weld with high efficiency deposit shall be of radiographic quality	IS: 814-91	EB 5326H2X heavy coated
A-5	Pipe welding or where high penetration of arc is needed	IS: 814-91	ER 4316X medium coated
B-1	Welding of steel component as steel to IS: 8500-91 GR.4408 & 4908, IS: 2002-92 GR. 1&2, IS: 1875-92 class 2, 2A & 3 or similar suitable for repair welding of cast steel to IS:1030 GR. 230-450W. The weld deposit shallbe of Radiographic quality Joining of stainless steel type 3CR 12, IRS M-44 or its equivalent with Milo steel / low alloyed steel/corten steel	IS: 814-91	EB5426H3X medium coated
B-2	Application same as B-1 above with high deposition efficiency	IS: 814-91	EB5426H3JX heavy coated
B-3	Fabrication of components made of steel to ASTM 516 GR. 70 or equivalent where low temperature (AT-46^{o}C) impact properties are required. The weld deposit shall be of Radiographic quality.	IS: 1395-B2	E55BC126 heavy coated
B-4	Application same as B-3 above with high deposition efficiency.	IS: 1395-B2	E55BC126J heavy coated
C-1	Fabrication of components made of steel to IS: 8500-91 GR.5408, 5708, 590, IS: 2002-92 GR.3, IS: 1875-92 class 3A or similar. The weld deposit shall be of radiographic quality.	IS: 1395-B2	E63BD126 heavy coated
C-2	Application same as C1 above with high deposition efficiency.	IS: 1395-B2	E63BD126J heavy coated

ISR CLASS	USE	IS/AWS SPEC.	IS/AWS CODE
D	Fabrication of component made of weathering steels conforming to IRSM-41 or M-42 with same steel or steels to IS: 2062-99, IS: 2002-92, IS: 1875-92 & IS: 8500-91 as mentioned above. This can also be used for combination joint of IRSM-41 & M-42. The weld deposit shall be of radiographic quality.	AWSA55	E8018W2 heavy coated
E-1	For fabrication & repairing of buckles, gear cases, protector tubes, door patches, side panels, end wall patches etc. of rolling stock & locomotives. The electrodes shall be low heat input type with 350 mm length.	IS: 814-91	ES4213X medium coated
E-2	Repair welding of bogies, both cast & fabricated. The electrodes shall be low heat input type	IS: 1395-82	E55BG1Ni26 heavy coated
F	For reclamation of cast iron with non-machineable deposit.	IS: 5511-91	EfcB26 medium coated
G	For welding of cast iron with machineable deposit (NI-FE type core wire). Also suitable for joining of cast iron to other ferrous & non-ferrous materials.	IS: 5511-91	ENIFeG16 Medium coated
H3s	For resurfacing of fabricated medium-Mn steel or cast Mn. Steel to withstand a traffic of 15 GMT minimum	IS: 5511-91	ENIFeG16 Medium coated
H3A s	Application same as H3 above to withstand a traffic of 25 GMT minimum.	IS: 5511-91	ENIFeG16 Medium coated
H3B s	Application same as H3 above to withstand a traffic of 35 GMT minimum.	IS: 5511-91	ENIFeG16 Medium coated
H3C s	Application same as H3 above to withstand a traffic of 50 GMT minimum.	IS: 5511-91	ENIFeG16 m/coated
H4A	For non-machineable hard facing of ferrous items with hardness range of 55-62 Rc	IS: 7303-74	Efe-IC314 heavy coated

ISR CLASS	USE	IS/AWS SPEC.	IS/AWS CODE
L	For welding of aluminium and aluminium alloys	AWS A5, 3	AL-43 medium coated
M1	For fabrication of stainless steels type 18% Cr 8% Ni types its equivalent.	IS: 5206-83	E19.9R26 heavy coated
M2	For fabrication of ferritic stainless steels type 3Cr12IRS M-44 or its equivalent, also suitable for fabrication of 18% Cr 8% Ni stainless steels with low carbon.	IS: 5206-83	E19.9R26 heavy coated
M3	For fabrication of stainless steels to ASTM grade 316 or its equivalent.	IS: 5206-83	E19.12.2R26 heavy coated
M4	For joining of dissimilar stainless steels as mentioned in M1, M2 and M3 or their equivalent & also suitable for joining M1, M2 and M3 stainless steels as mentioned above or their equivalent with mild steel or low alloyed steel. Also be used for welding of heat resisting stainless steels 22% Cr 12% Ni type or its equivalent.	IS: 5206-83	E23.12R26 heavy coated
M5	For joining of manganese steel liners and other austenitic manganese steel components with steel casting to IS: 1030 Gr.230-450W/280-520W or to IS: 2062	IS: 5206-83	E18.8MnB26 heavy coated
M6	For repair welding of cracked gas inlet casting of diesel locomotives. Used for other repair welding of stainless steels casting having higher percentage of carbon and for welding of high heat resisting stainless steels 25% Cr 20% Ni type or its equivalent.	IS: 5206-83	E25.20R26 heavy coated
N-1	For cutting mild steel low alloy steel, stainless steels, austentic manganese steels, cast iron cast steel & non-ferrous alloys such as nickel alloys, ALU, C, bronzes etc.	IS: 5206-83	E25.20R26 heavy coated
N-2	For gouging & piercing of steels and non-ferrous alloy as described in N1.	IS: 5206-83	E25.20R26 heavy coated
N-3	For gouging of mild & low alloy steel, stainless steels, austenitic manganese steel and cast iron & cast steel, copper coated graphitic type electrode.	IS: 5206-83	E25.20R26 heavy coated

36,34 WELDING DEFECTS

DEFECTS	EFFECTS	CAUSES	REMEDIES
SPATTER 	Deposition of weld metal in small pills around the joint	1. High current, long or instable arc. 2. Wrong polarity or damp electrode 3. Improper cleaning 4.wrong selection of electrode	1. Keep the correct amperes of current. 2. Medium and stable arc. 3. Select proper and dry electrode. 4.clean the welding area before welding
OVER LAP 	Excess layer of weld bead	1. Low speed or wrong angle of the electrode. 2. Improper weaving method 3. Wrong polarity	1. Medium speed and correct angle of electrode 2.Proper weaving method and 3.Correct arc length
UNDERCUT 	Grooves at toes of welding bead	1. High current 2. Excess weaving of electrode 3. Wrong selection of electrode	1.correct amperes 2.proper weaving of electrode 3.correct selection of electrode
SLAG INCLUSION 	Presence of foreign materials	1. Long arc. 2. Improper edge preparation. 3. Fast freezing of molten metal . 4. Wrong selection of electrode.	1. Maintain medium arc length. 2. Proper edge preparation. 3.Fast freezing of molten metal to be avoided. 4.Proper selection of electrode.
BLOW HOLE 	Large sized holes left behind in the weld bead	1. Use of damp or 2. rusty 3. electrodes. 4. Long arc. 5. Improper weaving.	1. Use dry electrodes and maintain medium arc length. 2. Proper weaving.
LACK OF PENETRATION 	Weld metal will not bind properly and poor strength. Crack may develop.	1. Low current 2. Improper edge preparation. 3. Fast speed	1. Correct amperes 2. Proper edge preparation. 3. Medium speed. 4. Weld the second layer after chipping the slag of first layer

CRACK 	Development crack in the weld in metal	1. Lack of penetration. 2. Improper edge preparation. 3. Sudden cooling of welded components. 4. Low current	1. Proper penetration. 2. Edge preparation. 3. Components to be cooled in atmospheric air. 4.correct amperes of current
DISTORTION 	Deformation of shape	1. Dissimilar metal thickness. 2. Lack of using jigs and fixtures. 3.improper tack weld	1.Use similar thickness of metal. 2. Use jigs and fixtures 3. Proper tack weld.
SPATTERS 	Swinging of weld metal to the weld line	1. Use of wrong electrode . 2. Wrong technique. 3. High current.	1.proper electrode 2. Proper welding technique. 3. Correct amperes of current.
CRATER 	Development of a pit at the weld line end	Incomplete layer of welding bead	At end of weld line the electrode should be kept for a while.
SURFACE PORES 	Formation of small holes in the weld bead	1.High current, 2.electrode damp or its flux is broken. 3.long arc	1. Correct amperes of current.2. dry electrodes with proper flux coating.3. Medium arc length.
LACK OF FUSION 	Insufficient melting of both parent and weld metals	1. Improper arc length. 2. Wrong type of electrode. 3. wrong weaving method.	1.Medium arc length. 2.Proper type of electrode. 3.Proper weaving method.

ACEPTANCE CRITERIA FOR VISUAL INSPECTION OF WELDS IN ACCORDANCE WITH ISO:5817/2007

NO	IMPERFECTION DESIGNATION	ACCEPTANCE CRITERIA
1.1	Crack	NOT PERMITTED
1.2	Crater crack	
1.3	Surface pore	
1.5	Lack of fusion(incomplete fusion)	
1.6	Incomplete root penetration	
1.7	Continuous & intermittent undercut (class C)	h<0.1t mm, but 0.5mm max
1.8	Shrinkage groove	h<0.05t, but 0.5mm max
1.9	Excess weld metal (butt weld)	h<0.15b+1mm,but 7mm max
1.11	Excess penetration	0.2b+1mm,but 3mm max
1.13	Overlap	NOT PERMITTED
1.14	sagging ,incompletely filled weld	h<0.05t,but 3mm max
1.16	Excessive Asymmetry of fillet weld (Excessive unequal leg)	1.5mm+ 0.15a max
1.17	Root concavity	h<0.05t but0.5mm max
1.18	Root porosity	NOT PERMITTED
1.19	Poor restart	NOT PERMITTED
1.2	Insufficient throat thickness	NOT PERMITTED
1.21	Excess throat thick(class c)	h<0.2a+1mm,but 4mm max
1.22	Stray arc	NOT PERMITTED
1.23	Spatter	not permitted
3.1	Linear misalignment	h<0.1t,but 3mm max
3.1 1	1. plates& longitudinal welds	
	2.circumferential welds	
3.2	Incorrect root gap for fillet weld	h<0.5mm+0.1a,but max 2mm

h - Height or depth of imperfection

b- Width of weld reinforcement

t- Thickness of job / plate (nominal size of parent metal)

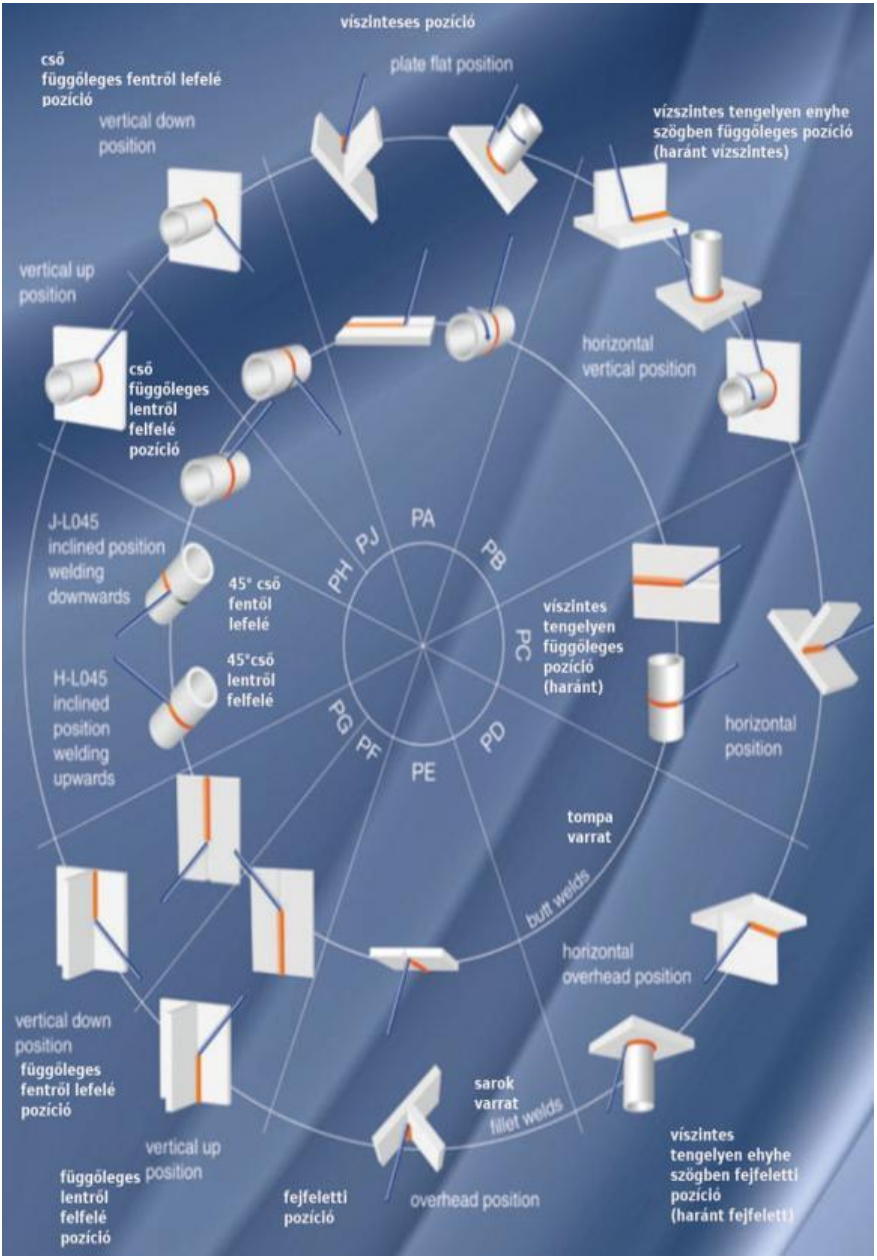
S-nominal butt weld thickness

l - Length of imperfection in longitudinal direction of weld

a - nominal throat thickness of fillet weld

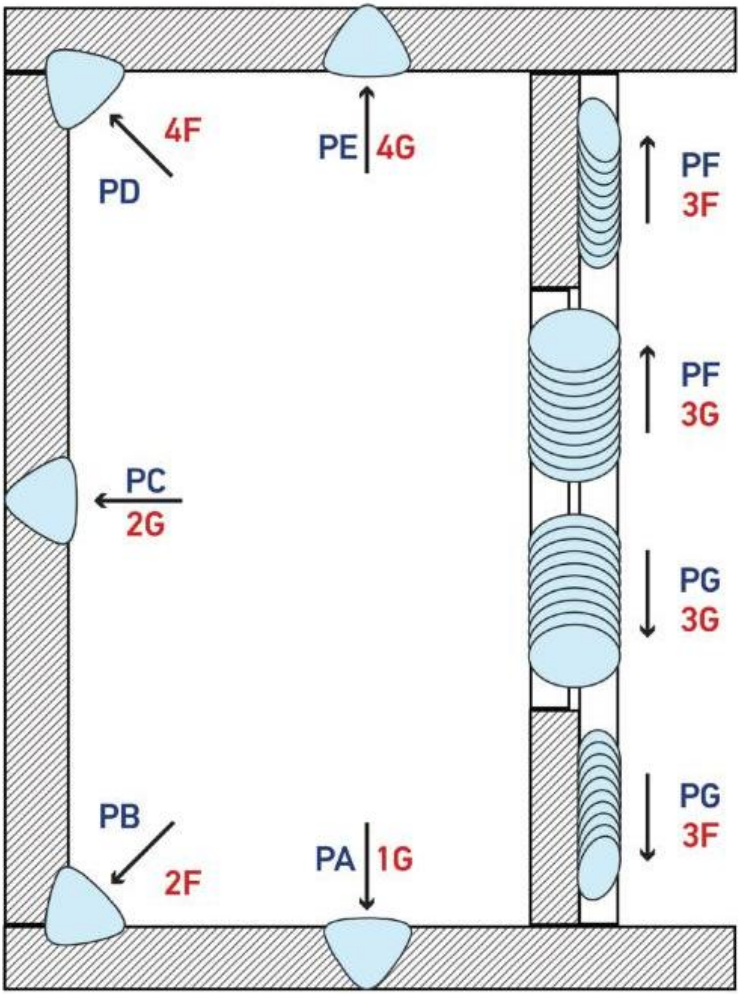
l - Length of imperfection in longitudinal direction of weld

WELDING POSITIONS

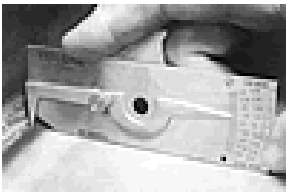


WELDING POSITIONS

ACCORDING TO PN-EN AND AWS/ASME



MEASURING DEVICESFOR WELDING JOINTS

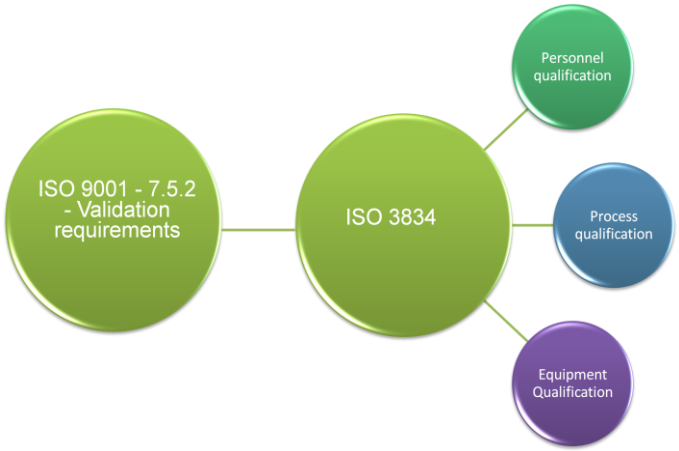


- Measuring tape – 1mm or finer
- Vernier calipers
- Feeler gauge – 0.1mm to 3mm
- Radius gauge

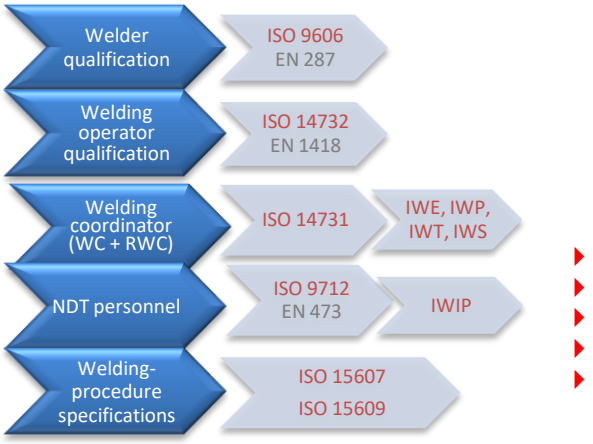
WHAT IS ISO-3834

- ISO 3834 is a Quality requirement for fusion welding of metallic materials.
- It is an international standard created by the welding professional.
- ISO 9001 defines overall requirements for quality management system.
- ISO-3834 standard specifies the requirements relating only to the welded structure.
- ISO 3834 is not a product standard, but it is often cited as a requirement of various products to ensure good practice in the welding and to prevent premature failures.
- ISO 3834 standard provides details of how to control the various welding and welding-related operations to achieve the desired quality consistently.

CONCEPT OF ISO 3834



QUALIFICATION REQUIREMENT



COMPREHENSIVE QUALITY REQUIREMENT (ISO-3834-Part-2)

➢ **Constructions in which the failure of welds may lead to**

- Total product failure
- With significant financial consequences
- Major injury.
- The product may be subject to dynamic loading in addition to high static loading.

WELDING PROCEDURE SPECIFICATION – WPS

➢ The Requirement of WPS is to determine that the weldment is capable of providing the required properties for the intended application.

➢ WPS establishes the properties of the weldment and not the skill of the welder.

➢ It is a written document that provides direction to the welder for making production weld in accordance with requirements.

➢ All WPS must be qualified.

➢ WPS specifies the condition (ranges) under which welding must be performed.

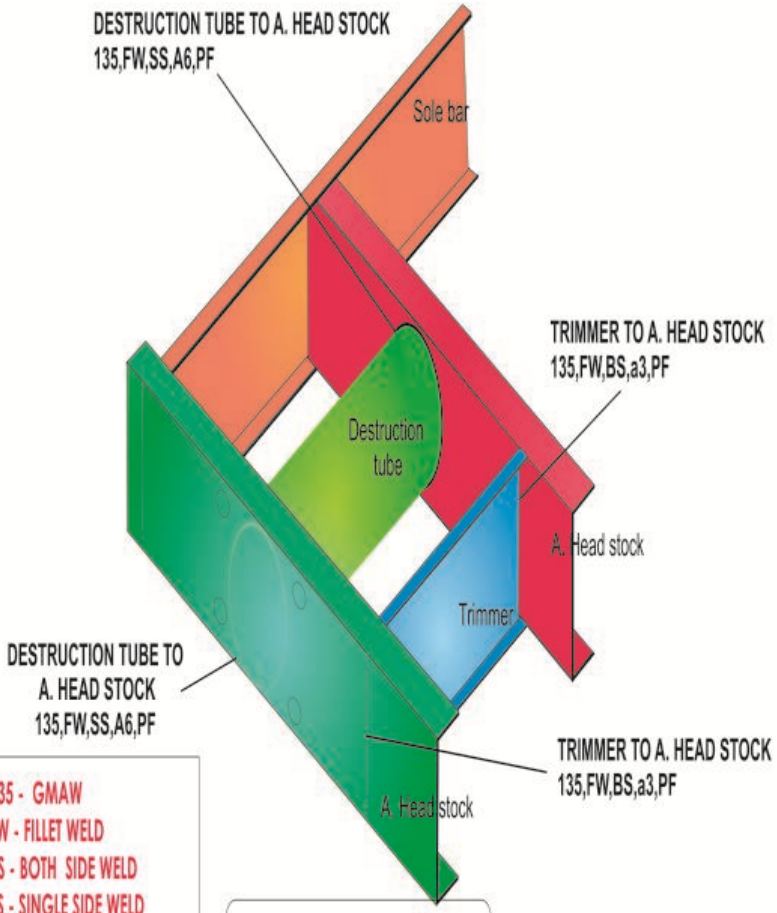
➢ WPS addresses essential and non essential variables.

➢ It documents what occurred during welding the test specimen and the results of the test specimen.

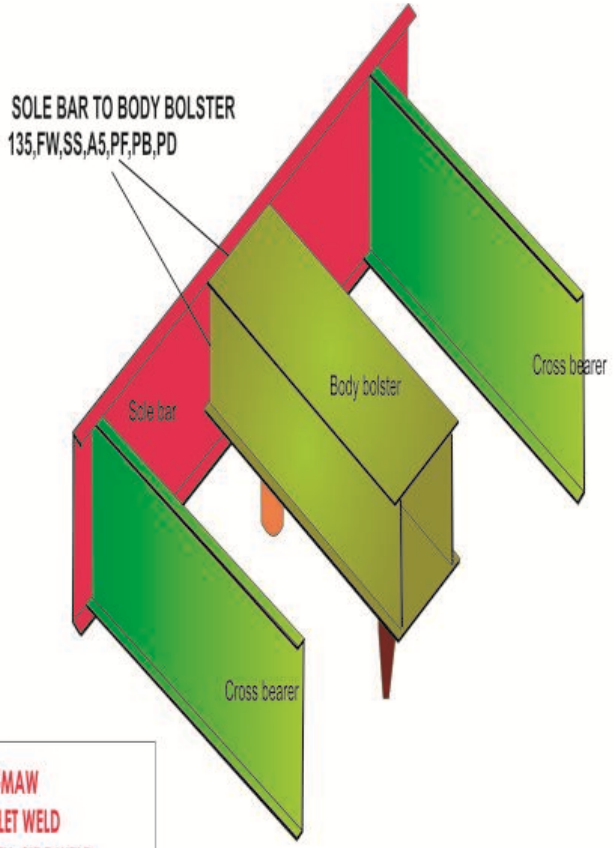
➢ PQR documents the essential variables and other specific information and the results of the required testing.

➢ Welder should follow the appropriate WPS to obtain good weldment.

DESTRUCTION TUBE AND TRIMMER RENEWAL



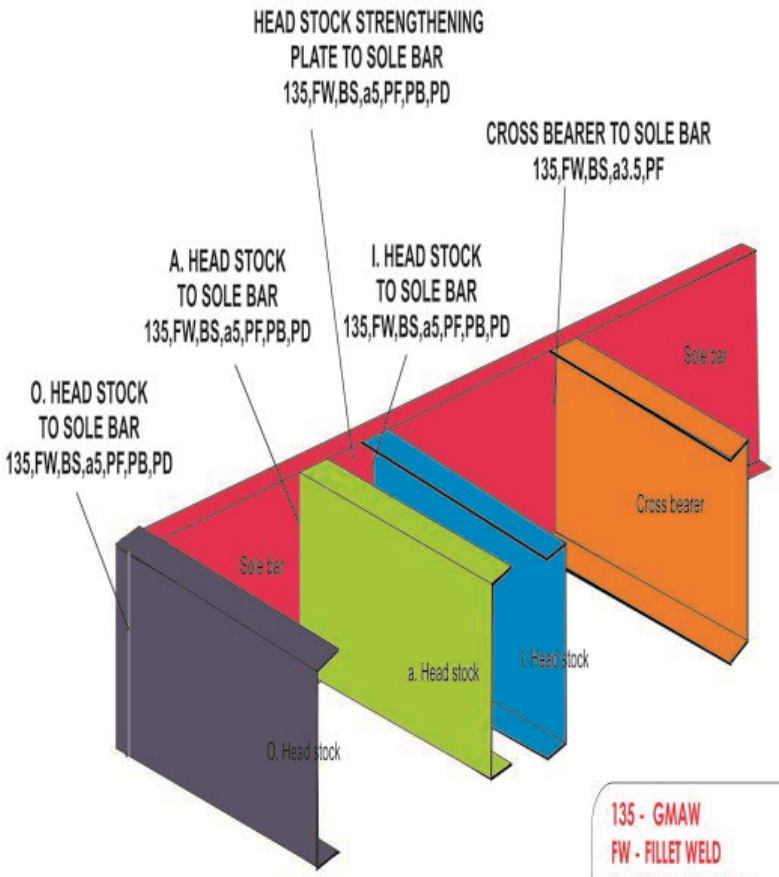
SOLE BAR AND BODY BOLSTER RENEWAL



135 - GMAW
FW - FILLET WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT SIZE in mm
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
PD-OVER HEAD POSITION

Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "D"
E8018 W2AWS5.5
GMAW - IRS M46 CLASS IV

SOLE BAR, HEAD STOCK, CROSS BEARER RENEWAL

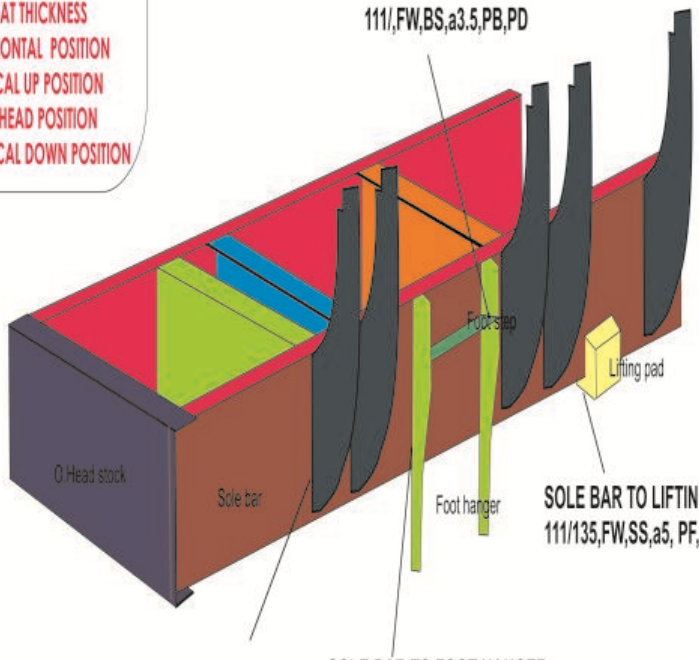


Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "D"
E6018 W2AWS5.5
GMAW - IRS M46 CLASS IV

135 - GMAW
FW - FILLET WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT SIZE in mm
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
PD- oVER HEAD POSITION

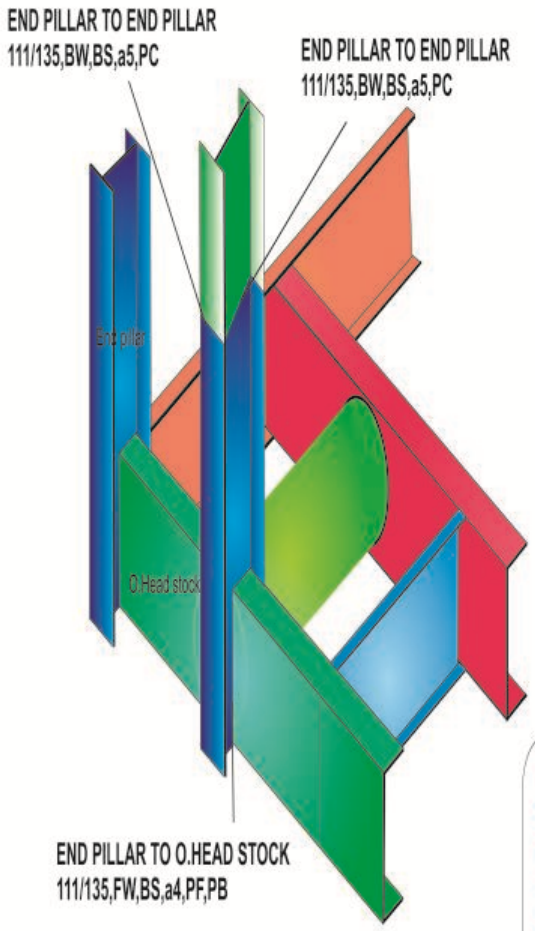
PART PILLAR, LIFTING PAD, FOOT HANGER, FOOT STEP RENEWAL

111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
PD- OVER HEAD POSITION
PG- VERTICAL DOWN POSITION



Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "D"
E8018 W2AWS5.5
GMAW - IRS M46 CLASS IV

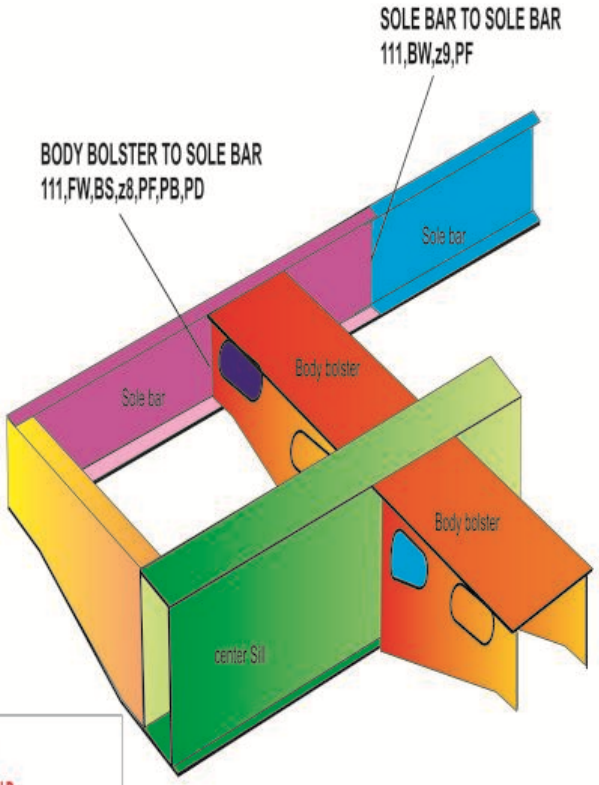
END PILLAR RENEWAL



Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "D"
E8018 W2AWS5.5
GMAW - IRS M46 CLASS IV

111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION

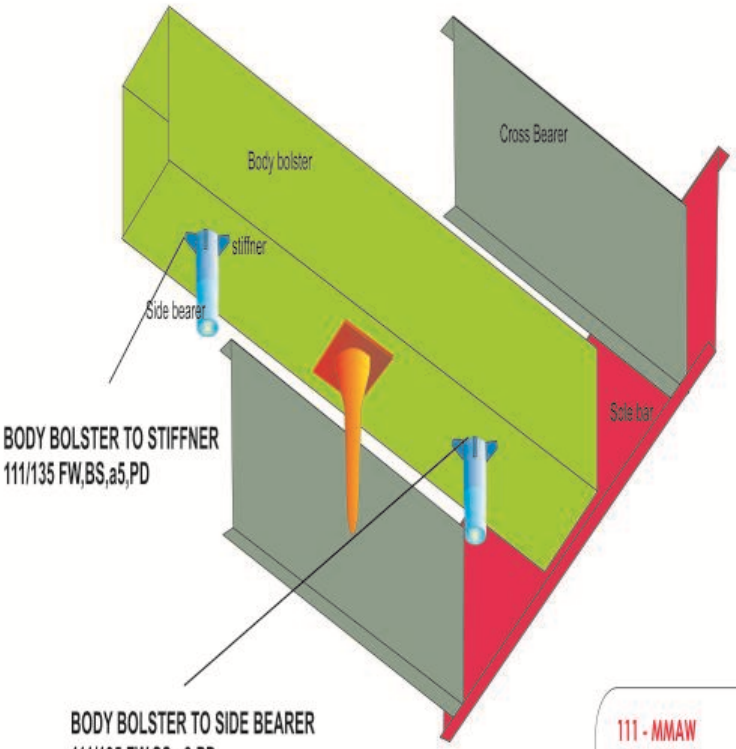
RENEWAL /PART REPLACEMENT OF SOLE BAR DURING POH



111 - MMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
z - LUG LENGTH IN mm
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
PD- OVER HEAD POSITION

Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "D"
E8018 W2AWS5.5
GMAW - IRS M46 CLASS IV

SIDE BEARER RENEWAL AS ASSEMBLED CONDITION

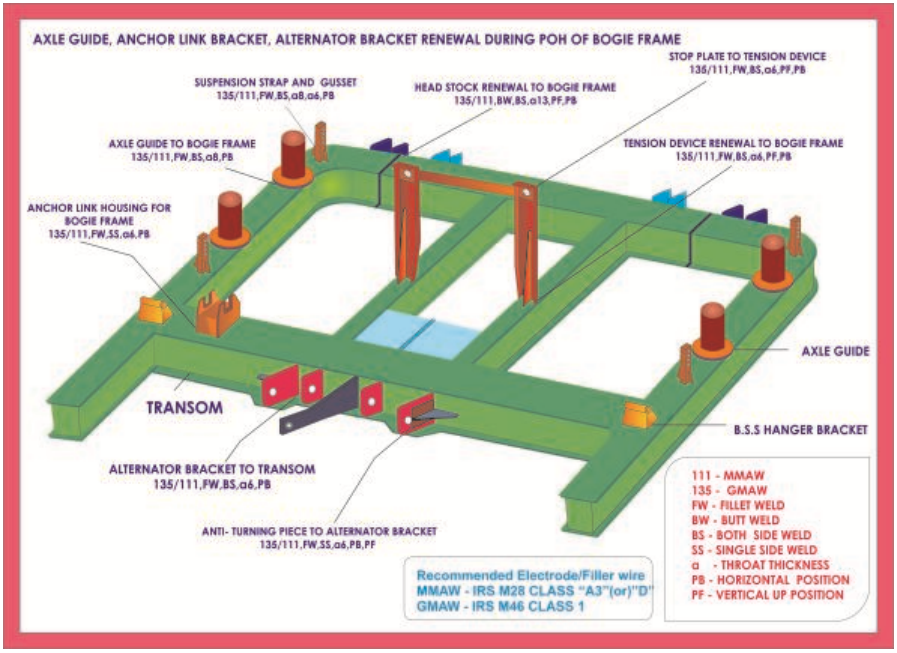


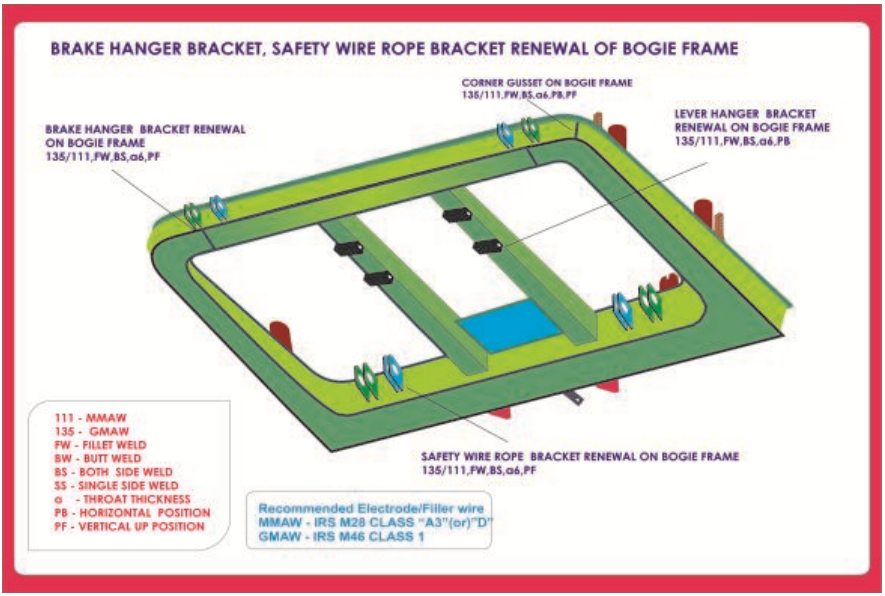
BODY BOLSTER TO STIFFNER
111/135 FW,BS,a5,PD

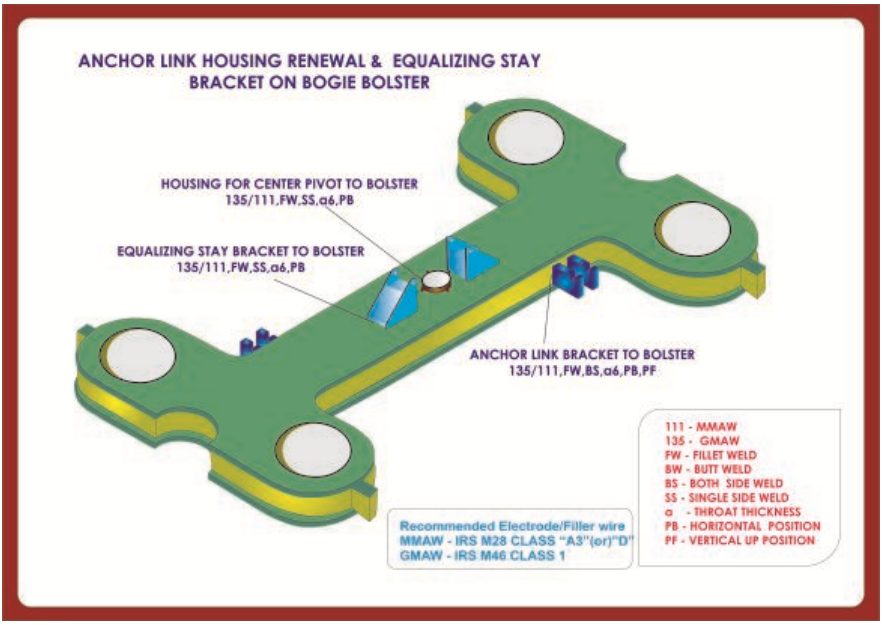
BODY BOLSTER TO SIDE BEARER
111/135 FW,SS,a8,PD

Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "D"
E8018 W2AWS5.5
GMAW - IRS M46 CLASS IV

111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PD- OVER HEAD POSITION


AXLE GUIDE, ANCHOR LINK BRACKET, ALTERNATOR BRACKET RENEWAL DURING POH OF BOGIE FRAME
STOP PLATE TO TENSION DEVICE 135/111,FW,BS,a6,PF,PB
SUSPENSION STRAP AND GUSSET 135/111,FW,BS,a8,a6,PB
HEAD STOCK RENEWAL TO BOGIE FRAME 135/111,BW,BS,a13,PF,PB
AXLE GUIDE TO BOGIE FRAME 135/111,FW,BS,a8,PB
TENSION DEVICE RENEWAL TO BOGIE FRAME 135/111,FW,BS,a6,PF,PB
ANCHOR LINK HOUSING FOR BOGIE FRAME 135/111,FW,SS,a6,PB
AXLE GUIDE
TRANSOM
B.S.S HANGER BRACKET
ALTERNATOR BRACKET TO TRANSOM 135/111,FW,BS,a6,PB
ANTI- TURNING PIECE TO ALTERNATOR BRACKET 135/111,FW,SS,a6,PB,PF
Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "A3"(or)"D"
GMAW - IRS M46 CLASS 1
111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION


BRAKE HANGER BRACKET, SAFETY WIRE ROPE BRACKET RENEWAL OF BOGIE FRAME
CORNER GUSSET ON BOGIE FRAME 135/111,FW,BS,a6,PB,PF
LEVER HANGER BRACKET RENEWAL ON BOGIE FRAME 135/111,FW,BS,a6,PB
BRAKE HANGER BRACKET RENEWAL ON BOGIE FRAME 135/111,FW,BS,a6,PF
SAFETY WIRE ROPE BRACKET RENEWAL ON BOGIE FRAME 135/111,FW,BS,a6,PF
111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "A3"(or)"D"
GMAW - IRS M46 CLASS 1


ANCHOR LINK HOUSING RENEWAL & EQUALIZING STAY BRACKET ON BOGIE BOLSTER
HOUSING FOR CENTER PIVOT TO BOLSTER 135/111,FW,SS,a6,PB
EQUALIZING STAY BRACKET TO BOLSTER 135/111,FW,SS,a6,PB
ANCHOR LINK BRACKET TO BOLSTER 135/111,FW,BS,a6,PB,PF
111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "A3"(or)"D"
GMAW - IRS M46 CLASS 1


ANCHOR LINK HOUSING RENEWAL & EQUALIZING STAY BRACKET ON BOGIE BOLSTER
ANCHOR LINK BRACKET TO BOLSTER 135/111,FW,BS,a6,PB,PF
CENTER PIVOT HOUSING TO BOLSTER 135/111,FW,SS,a6,PB
111 - MMAW
135 - GMAW
FW - FILLET WELD
BW - BUTT WELD
BS - BOTH SIDE WELD
SS - SINGLE SIDE WELD
a - THROAT THICKNESS
PB - HORIZONTAL POSITION
PF - VERTICAL UP POSITION
Recommended Electrode/Filler wire
MMAW - IRS M28 CLASS "A3"(or)"D"
GMAW - IRS M46 CLASS 1