

IRS M: 28-2012

भारत सरकार

GOVERNMENT OF INDIA

रेल मंत्रालय

MINISTRY OF RAILWAYS

; रेलवे बोर्ड

(RAILWAY BOARD)



**INDIAN RAILWAY STANDARD SPECIFICATION
FOR
CLASSIFICATION, TESTING AND ACCEPTANCE CRITERIA
OF MANUAL METAL ARC WELDING ELECTRODES AND
GAS WELDING RODS**

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Indian Railway Standard Specification For Classification, Testing And Acceptance Criteria Of Manual Metal Arc Welding Electrodes And Gas Welding Rods

O. FOREWORD

- 0.1 This specification is issued under the fixed serial No. M- 28, the final number indicates the year of original adoption as standard, or in the case of revision, the year of last revision.

ADOPTED 1976: REVISED 1986 , 2002 & 2012

- 0.2 This specification is issued to facilitate selection and procurement of manual metal arc welding electrodes and gas welding rods by Indian Railways for welding of structural steels, non-ferrous metals & alloys & other components in place of existing **IRS M: 28-02**. It also covers various cutting , gouging, repair and reclamation electrodes used by Indian Railways.

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0.3 The selection of a correct type of electrode or gas welding rod for specific application is a very important consideration in Metal Arc/Gas Welding. In this regard, the Bureau of Indian Standards has issued the following specifications: -

IS: 814-2004 : Covered electrodes for manual metal arc welding of Carbon and Carbon Manganese Steel

IS: 1395-2003: For low and medium alloy steel covered electrodes for manual metal arc welding

IS: 8666-2003: Copper and copper alloy covered electrode for manual metal arc welding.

IS: 5206-2003: Covered electrodes for manual metal arc welding of stainless Steel & other similar high alloy steels.

IS: 5511-2003: Covered electrodes for manual metal arc welding of cast iron.

IS: 7303-2003: Covered electrodes for surfacing of metal by manual metal arc welding.

IS: 1278-2003: Filler rods for gas welding.

0.4 Considering that the above specifications do not fully cover the requirements of Metal Welding Electrodes/Gas Welding Rods used for various applications on the Indian Railway such as in the construction and repairs of Rolling Stock, Structures, Bridges Permanent Way etc., it was considered necessary to lay down classification of Metal Arc Welding Electrodes/Gas Welding Rods, their testing and acceptance criteria for specific requirements of Railways.

0.5 Considering the need of IR for electrodes suitable for joining many new types of metals which has progressively come into the market, some basic changes have been done in classification of electrode for welding of structural steels.

Basically, all the structural steels and cast steel covered by IS 2062, 1875 & 1030, 2002 latest versions have been divided in three categories based on their UTS and Y.S. Again in these classes, different uses have been identified i.e. static, moderately dynamic, highly dynamic and low temperature application. For each type of material & end use, a specific electrode class has been allotted. Separate class has been made for joining corten steel conforming to IRS M-41 & M-42 ,Stainless steels to IRS M-44,AISI grades 301,304, 310, 312,316 etc.

Parent Material	Use	Class of electrode
Low tensile steel	Static	A1
-do-	Mod. Dynamic	A2
-do-	Highly Dynamic/low temp	A3, A4
Pipe welding	All application	A5
Medium Tensile steel	All standard application	B1, B2
-do-	Low temperature application below -20°C	B3, B4
High Tensile steel	All application	C1, C2
Corten to IRS M-41 & IRS M-42	All application	D
Low & medium tensile steel	Low heat input welding	E1 & E2
Cast irons	For reclamation & repair	F&G
Ferrous components	Hard facing of ferrous components	H series
Non ferrous metal & alloys(Cu & Al)	All application	K & L
Stainless Steels of various grades	All application	M series
All ferrous & non ferrous metal & alloys	For cutting & gouging	N1,N2&N3

0.6 Based on experience and feed back from user Railways, some changes have been made in M series of electrodes to avoid confusion. One more class M7 has been introduced for joining of cast ferrous alloys of similar composition, dissimilar metals such as carbon steels to stainless steels & welding of steels of unknown compositions. Specific class has been identified for sheet metal welding. Chemical composition of class A3,A4,B1,B2 has been included. As the steam locomotives have become obsolete progressively, the requirement of non-ferrous items and welding thereof has come down. Hence, the classifications of these types of electrode have been trimmed to basic minimum.

0.7 In framing this specification, necessary assistance has been derived from the specification as mentioned in clause 0.3 and also the following AWS specifications :-

AWS A5.5	Low Alloy Steel Covered Arc Welding Electrodes.
AWS A5.3	Aluminium and Aluminium Alloy Arc Welding Electrodes.

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0.8 Packing conditions for both MMAW electrodes and Gas welding rods have been incorporated in Clause 5. The same has been kept as requirement of acceptance also.

0.9 Wherever a reference to any other standard appears in this specification, the latest version of the same shall be referred to.

0.10 For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS: 2-2000 “Rules for rounding off numerical values (revised)”. The number of significant places retained in the rounded off values shall be the same as that of the specified value in this standard.

1. **Scope:**

This standard lays down the classification, acceptance requirements and procedure for selection, testing and grading of different classes of manual metal arc welding electrodes/gas welding rods for use on Indian Railways.

2. **Definition:**

2.1 **Manufacturer:** Manufacturer means the indigenous unit manufacturing Metal Arc Welding Electrodes/Gas Welding Rods. A manufacturer must have complete infrastructure required for production along with testing & quality control facilities. All the facilities must be located in single premises under its ownership dedicated to the production of subject items.

2.2 **Sister Concern:** Sister Concern means a separate production unit of the same concern or separate production unit under same administrative control. For the purpose of this specification, each such production units located in different premises will be treated as different firm.

3. **Classification:**

3.1 The electrodes have been classified into 33 different classes i.e. A1, A2, A3, A4, A5, B1, B2, B3, B4, C1, C2, D, E1, E2, F, G, H3, H3A, H3B, H3C, H4A, H4B, K, L, M1, M2, M3, M4, M5, M6, M7, N1, N2 & N3.

The purpose for which each class of electrode is to be used, together with the IS/AWS code and type of coating, is given in **Table 1**.

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TABLE –1

(Cl. 3.1)

**CLASSIFICATION OF ELECTRODES AS PER THEIR APPLICATION
ALONG WITH IS/AWS SPECIFICATION AND CODING THEREOF**

Sl. No .	IRS Class	Purpose of use	IS/AWS Specification	IS/AWS Code*
1.	A1	Fabrication of component meant for static application made of steels to IS: 2062-11 Gr.E250 Quality A, IS:1875-04 Class I & IA or equivalent. Suitable for joining steel sheets to IS: 513-98, IS: 1079-94 & Gr. Fe 330 to IS: 5986-02 or equivalent and for repair welding of cast steels to IS: 1030-98 Gr. 200-400W. This electrode can also be used for welding where strength requirement is not specified.	IS: 814-04	ER4112 (Medium coated)
2.	A2	Fabrication of component meant for semi-dynamic application such as bridges etc., made of steel to IS: 2062-11 Gr.E250 Quality BR&B0, IS: 1875-04 Class I & IA or similar. The weld deposit shall be of radiographic quality.	IS:814-04	ER4211X (Medium coated)
3.	A3	Fabrication of component meant for highly dynamic application made of steels to IS: 2062-11 Gr.E250 quality C or for other applications where low temperature impact property is required. The weld deposit shall be of radiographic quality.	IS:814-04	EB5326H2X (Heavy coated)
4.	A4	Application same as A3 above with high deposition efficiency	IS:814-04	EB5326H2JX (Heavy coated)
5.	A5	For pipe welding or other applications where high penetration of arc is needed.	IS:814-04	EC4316X (Medium coated)

Sl. No	IRS Class	Purpose of use	IS /AWS specification	IS/AWS Code *
6	B1	Fabrication of component made of steels to IS: 2062-11 Gr.E300 & E350 all quality, IS: 2002-01 Gr. 1 & 2, IS: 1875-04 Class 2, 2A and 3 or similar. Also suitable for repair welding of cast steels to IS: 1030-98 Gr. 230-450W. The weld deposit shall be of radiographic quality. Also for joining of stainless steels type 3Cr12, IRS M-44 or its equivalent with mild steel/ low alloyed steel/ Corten steel.	IS:814-04	EB5426H3X (Heavy Coated)
7	B2	Application same as B1 above with high deposition efficiency	IS:814-04	EB5426H3JX (Heavy coated)
8	B3	Fabrication of components made of steels to ASTM 516 Gr.70 or equivalent where low temperature (at -46°C) impact properties are required. The weld deposit shall be of radiographic quality.	IS:1395-03	E55BC126 (Heavy coated)
9	B4	Application same as B3 above with high deposition efficiency	IS:1395-03	E55BC126J (Heavy coated)
10	C1	Fabrication of component made of steels to IS: 2062-11 Gr.E410, 450, IS: 2002-01 Gr. 3, IS: 1875-04 Class 3A or similar. The weld deposit shall be of radiographic quality.	IS:1395-03	E63BD126 (Heavy coated)
11	C2	Application same as C1 above with high deposition efficiency	IS:1395-03	E63BD126J (Heavy coated)
12	D	For joining weathering steels conforming to IRS M-41 or M-42 with same steel or steels to IS: 2062-11 IS: 2002-01 & IS: 1875-92 as mentioned above. This can also be used for combination joint of IRS M-44 & IRS M-41 and IRS M-41 & M-42. The weld deposit shall be of radiographic quality.	AWS A5.5	E8018W2 (Heavy coated)

Sl. No	IRS Class	Purpose of use	IS /AWS specification	IS/AWS Code *
13.	E1	For fabrication & repairing of Buckles, Gear cases, Protector Tubes, Door Patches, Side panels, End wall patches etc. of Rolling stock & locomotives. The electrode shall be low heat input type **. With 350 mm length.	IS:814-04	ER4211X (Medium coated)
14.	E2	For repair welding of bogies, both cast and fabricated. The electrode shall be low heat input type ** with 350 mm length.	IS:1395-03	E55BG1Ni26 (Heavy coated)
15	F	For reclamation of cast iron with non-machinable deposit.	IS: 5511-03	EFe B26 (Medium coated)
16	G	For welding of cast iron with machinable deposit (Ni-Fe type core wire). Also suitable for joining of cast iron to other ferrous and non-ferrous materials.	IS:5511-03	ENiFeG16 (Medium coated)
17	H3 [§]	For resurfacing of fabricated Medium-Mn steel or Cast Mn. Steel crossings to withstand traffic density of 15 GMT minimum.	-	-
18.	H3A [§]	Application same as H3 above to withstand traffic density of 25 GMT minimum.	-	-
19	H3B [§]	Application same as H3 above to withstand traffic density of 35 GMT minimum.	-	-
20	H3C [§]	Application same as H3 above to withstand traffic density of 50 GMT minimum.	-	-
21	H4A	For non-machinable hard facing of ferrous items with hardness range of 55-62Rc.	IS:7303-03	EFe-1C314 (Heavy coated)
22	H4B	For machinable hard facing of ferrous items with hardness range of 30-40 HRc like reclamation of Equalising beam etc.	IS:7303-03	EFe-B314 (Heavy coated)
23	K	For welding of copper, bronze and other copper alloys including Gun-metal.	IS:8666 -03	ECuSn-A (Medium coated)

Sl. No	IRS Class	Purpose of use	IS /AWS specification	IS/AWS Code *
24	L	For welding of aluminium & aluminium alloys.	AWS A5.3	AL-43 (Medium coated)
25	M1 [@]	For fabrication of stainless steels type 18%Cr 8%Ni type or its equivalent	IS:5206-03	E19.9R26 (Heavy coated)
26	M2 [@]	For fabrication of stainless steels type 3 Cr12, IRS M-44 or its equivalent. Also suitable for fabrication of 18%Cr 8%Ni stainless steel with low carbon.	IS:5206-03	E19.9LR26 (Heavy coated)
27	M3 [@]	For fabrication of stainless steels type 316 or its equivalent.	IS: 5206-03	E19.12.2R26 (Heavy coated)
28	M4 [@]	For fabrication of ferritic stainless steels type 3Cr12, IRS M-44 or its equivalent. Also suitable for joining dissimilar stainless steels as mentioned in M1, M2 and M3 or their equivalent. This is also suitable for joining M1, M2 and M3 type of stainless steels as mentioned above or their equivalent with mild steel or low alloyed steel. This can also be used for welding of heat resisting stainless steels 22%Cr 12%Ni type or its equivalent.	IS: 5206-03	E23.12LR26 (Heavy coated)
29	M5 [@]	For joining of manganese steel liners and other austenitic manganese steel components with steel casting to IS: 1030-98 Gr. 230-450W/280-520W or to IS: 2062-11	IS: 5206-03	E18.8MnR26 (Heavy coated)
30	M6 [@]	For repair welding of cracked gas inlet casing of diesel locomotives. These can also be used for other repair welding of stainless steel castings having higher percentage of carbon and for welding of high heat resisting stainless steels 25%Cr 20%Ni type or its equivalent.	IS: 5206-03	E25.20R26 (Heavy coated)
31	M7	For joining of cast ferrous alloy of similar composition, dissimilar metals such as carbon steels to stainless steels & welding of steels of unknown compositions.	IS: 5206-03	E29.9R26 (Heavy coated)
32.	N1 [#]	For cutting mild steels, low alloy steels, stainless steels, austenitic manganese steels, cast iron, cast steel & non-ferrous alloys such as Nickel alloys, Al, Cu, Bronzes etc.	-	-

Sl. No	IRS Class	Purpose of use	IS /AWS specification	IS/AWS Code *
33.	N2 [#]	For gouging & piercing of steels and non-ferrous alloys as described above in class N1.	-	-
34.	N3 [#]	For gouging of mild steels, low alloy steels, stainless steels, austenitic manganese steels, and cast iron & cast steel. The electrode shall be of copper-coated graphitic type.	-	-

* IS/AWS code is for the purposes as explained in Cl. 3.2.

** An electrode shall be called “Low Heat Input Type” provided it runs with Max.70V OCV at the current ranges mentioned below:

Electrode Diameter	Current Range(Amps)
2.5 mm X 350mm	60-90
3.15mm X 350mm	90-120
4.00mm X 350mm	120-150
5.00mm X 350mm	150-200

\$ Different electrodes of H3 series are under development. Proper IS code will be allotted after finalisation.

@ All stainless steel electrodes must have stainless steel core wire.

Current range of N series of electrodes shall be as given below:

Dia. of electrode In mm	Current range in Amp. AC(OCV 50)/DC(-)	
	N1	N2 &N3
2.5	130 – 180	150 - 200
3.15	150 – 230	200 - 250
4.0	200 – 300	250 - 350
5.0	250 – 350	350 - 400

Coating factors: For Medium – 1.36 to 1.50 and for Heavy-1.51 to 2.20

For any IRS class, no tender shall be published without mentioning its Code except in case of H3 & N series of electrodes.

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3.2 Standard code as per IS or AWS has been shown against each class of electrode except N class for type of covering, welding position and current condition only. For Mechanical properties and Chemical requirement, values stipulated in appropriate tables of this standard shall be followed. In areas not covered by this Standard, the views and conditions stipulated in the respective IS/AWS standard shall be followed.

3.3 The Gas Welding Rods have been classified into 4 different classes i.e. Class I to Class IV. The purpose for which each class of the Gas Welding Rod is to be used together with corresponding IS specification is given in **Table -2**.

TABLE – 2 (Cl. 3.3)

**CLASSIFICATION OF GAS WELDING RODS AND PURPOSE OF USE
ALONGWITH EQUIVALENT TYPES IN IS:1278-72**

IRS Class	Purpose of use	Equivalent type in IS:1278-03
Class I	General purpose low carbon mild steel rods meant for application where a minimum butt-weld strength of 35.0 kg/sq.mm. is required.	S-FSI
Class II	Mild steel rod intended for application in which minimum butt weld tensile strength 44 kgf/mm ² is required. It is not intended for general welding purpose.	S-FS2
Class III	Medium tensile steel rod intended for application where a minimum butt weld tensile strength of 50.0 kgf/mm ² is required.	S-FS3
Class IV	Silicon-Bronze(Brass) rods intended for Bronze welding(Brass welding) of copper & mild steel and fusion welding of materials of same or closely similar composition.	S-C6

4. Size of MMAW electrode/Gas Welding Rod:

- 4.1 For electrode classes A3-D, F, and H4 series, the standard length shall be 450mm for all the diameters except 2.5mm. For 2.5mm dia, the length shall be 350mm. For classes A1&A2, the standard length shall be 450mm for diameter 4.0mm & above. For diameter 2.5mm & 3.15mm, the length shall be 350mm.
- 4.2 For all other classes, the standard length shall be 350mm only.
- 4.3 Electrode shall be manufactured in the dia. of 1.6mm, 2.5mm, 3.15mm, 4mm, 5mm and 6.3mm, covering the range of lower size and higher size.
- 4.4 Gas welding rods shall be manufactured in the diameters as given in IS: 1278-91.
- 4.5 For gas welding rods, the standard length shall be 500mm for rod diameter less than 2.5mm and 1000mm for rod diameter 2.5mm and above with a tolerance of ± 5 mm.

5. Packaging:

- 5.1 **Standard Packing:** To guard against ingress of moisture and accidental damage during transportation and storage till its consumption, the packaging system of electrode shall be as detailed below:
 - 5.1.1 **For electrodes of Classes A1, A2, A5, E1, G, H4A, K, L, N1, N2 & N3:**
 - 5.1.1.1 Counted and weighed electrodes shall be kept in moisture proof polythene bag and sealed.
 - 5.1.1.2 The sealed bag shall further be kept in cardboard cartoons. Cartons shall have printed on it the name & address of the manufacturer, electrode brand name, IRS class with IS and/or AWS code, coating factor, batch no., date of manufacture, date of expiry, size, current condition & welding parameters, quantity, cautionary note on safety during welding and any other special recommendation.
If the quantity of electrodes are supplied in Kg, the corresponding numbers of electrodes shall be indicated in the packet and also in the inspection certificate as additional information.
 - 5.1.1.3 Total weight of the carton shall not exceed 7 kg.
 - 5.1.1.4 This carton shall be sealed and put in a polythene bag and sealed/shrink sealed.
 - 5.1.1.5 Counted number of sealed carton shall be kept in suitable wooden or cardboard box and stripped tightly to avoid damage during transportation.
 - 5.1.1.6 The details of packing may vary from one manufacturer to other, but in essence, it must have two moisture proof polythene layers with two cardboard boxes. At least one packing must be of shrink packed type however; the preheating of low hydrogen electrodes should be done as per technological development & the recommendation of the electrode manufacturer to avoid moisture pickup during use. The preheated electrodes should be kept at welding site in the Holding Oven at a temperature around 170 °C for better quality of weld.
 - 5.1.2 **For electrodes of Class H3 series and M series**
 - 5.1.2.1 As given in clause 5.1.1.1.

- 5.1.2.2 The sealed bag shall be further kept in plastic box with single opening at end. The box shall contain all the information as given in clause 5.1.1.2.
- 5.1.2.3 As given in Clause 5.1.1.3.
- 5.1.2.4 As given in Clause 5.1.1.4.
- 5.1.2.5 As given in Clause 5.1.1.5.

5.2 Vacuum packing: For Basic coated electrodes of classes A3, A4, B1, B2, B3, B4, C1, C2, D, E2, F & H4B which can be used without preheating if supply is given in vacuum packing, the vacuum packaging as follows:

5.2.1 If supplied in a vacuum, packing maximum 2Kg. of electrodes shall be packed in a pouch made of metal foil and hermetically sealed. The unit of quantity of electrodes to be supplied normally be expressed in running meter.

N.B-Option for vacuum packing (clause5.2) or standard packing(clause5.1) are to be decided by the consignee.

- 5.2.2 The pouch must contain the relevant information as given in Clause 5.1.1.2.
- 5.2.3 These pouches shall be kept in hard cardboard or wooden box and stripped tightly to prevent mechanical injury or accidental perforation of pouches during transportation, storage or handling.
- 5.2.4 Maximum weight of the box shall be limited to 7 kg.
- 5.3 **Gas Welding Rods:** For Gas Welding Rods, the packaging shall be as detailed below:
- 5.3.1 As given in Clause 5.1.1.1
- 5.3.2 The sealed bag shall further be kept in hard cardboard cartons. All the relevant information as given in clause 5.1.1.2 shall be printed on the carton except current condition.
- 5.3.3 As given in Clause 5.1.1.3
- 5.3.4 As given in Clause 5.1.1.4
- 5.3.5 As given in Clause 5.1.1.5

6. Requirements:

- 6.1 Electrodes/Gas welding rods must meet the relevant sub-clause of clause 4 & 5.
- 6.2 The requirements against each class of electrode have been indicated in **Table 3 & 4**. The minimum value requirement of each criteria is either given in the table or reference of appropriate Appendix and table has been made wherein the details of testing and minimum value requirement has been described.

TABLE 3 (Cl. 6.2)
REQUIREMENTS FOR 'A' to 'E' CLASS OF ELECTRODES

IRS Class	Performance Test *	Mechanical Properties	Chemical Composition	Radiography on Butt weld **	Hydrogen content ***	Deposition Efficiency #	Fillet weld test	Corr. Resistance
A1	App.-A	Table-5	-	-	-	-	-	-
A2	-do-	-do-	-	IIW Blue Std.	-	-	-	-
A3	-do-	-do-	Table-8/ App- B	-do-	H2	-	-	-
A4	-do-	-do-	- do-	-do-	-do-	110% - 130%	-	-
A5	-do-	-do-	-	-do-	-	-	-	-
B1	-do-	-do-	Table-8/ App- B	-do-	H3	-	-	-
B2	-do-	-do-	-do-	-do-	H3	110% - 130%	-	-
B3	-do-	-do-	-do-	-do-	H3			
B4	-do-	-do-	-do-	-do-	H3	110% - 130%		
C1	-do-	-do-	-do-	-do-	H3	-	-	-
C2	-do-	-do-	-do-	-do-	H3	110% - 130%	-	-
D	-do-	-do-	-do-	-do-	-do-	110% - 130%	Table- 7	App-D
E1	-do-	-do-	-	-do-	-	-	-	-
E2	-do-	-do-	Table-8/ App- B	-do-	H3	-	-	-

* Further tests shall be carried out only if the electrode is found satisfactory in this test.

** IIW Stands for International Institute of Welding.

***H1, H2 and H3 stand for 15 ml, 10ml and 5ml of diffusable hydrogen per 100 gm of weld respectively.

Tolerances in limiting values as given in respective IS/AWS are applicable.

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TABLE 4

(Cl. 6.2)

REQUIREMENTS FOR 'F' to 'N' CLASS OF ELECTRODES

AND G. W. RODS

IRS Class	Performance Test *	Usability Test	Mechanical Properties	Hardness	Chemical Composition	Fillet weld Test	Macro Examn.
F	App.- A	App-C	-	-	-	-	-
G	-do-	-do-	-	175 - 200 HB /App.- C	Table-10	-	-
H4A	-do-	-	-	55 - 62 Rc/ App.- F	Table- 9/ App.-F	-	App.- F
H4B	-do-	-	-	30 – 40 Rc/ App.- F	-do-	-	-do-
K	-do-	-	Table- 6	-	Table- 10	-	-
L	-do-	-	Table- 6	-	-do-	-	-
M1	-do-	-	-	-	Table- 9/ App.-B	Table - 7	-
M2	-do-	-	-	-	-do-	-do-	-
M3	-do-	-	-	-	-do-	-do-	-
M4	-do-	-	-	-	-do-	-do-	-
M5	-do-	-	-	-	-do-	-do-	-
M6	-do-	-	-	-	-do-	-do-	-
M7	-do-	-	-	-	-do-	-do-	-
N1	-do-	-	-	-	-	-	-
N2	-do-	-	-	-	-	-	-
N3	-do-	-	-	-	-	-	-
G. W. Rods	-	-	-	-	Table- 10	-	-

* Further tests shall be carried out only if the electrode is found satisfactory in this test.

- 6.2.1 **Performance test:** Performance Test includes Running Performance and Accelerated Storage Stability Test. There shall not be any adverse remark in Running Performance. In Accelerated Storage Stability test, there shall not be any cracking, blistering or peeling off of flux. The core wire inside flux coating shall not have gross corrosion. The Deposition Efficiency of a high deposition type of electrode, when determined after subjecting it to above test, shall not fall below the minimum acceptable limit of 110%. The details of test procedure are given in **Appendix- A**.
- 6.2.2 **Mech. Properties:** Mechanical properties required for electrode classes **A to E, and K & L** have been given in **Table 5 and 6** respectively. The base material requirement has also been specified for class K.

TABLE – 5 (Cl. 6.2.2)

**MINIMUM REQUIREMENTS OF MECHANICAL PROPERTIES FOR
IRS CLASS ‘A’ to ‘E’**

IRS Class	All Weld properties					Transverse Bend Test with 3T mandrel dia. at 180° (both face & root)
	UTS in N/mm^2	YS in N/mm^2	% Elongation on 5d G. L.	% Reduction in area	Impact in Joule	
A1	410	330	24	50	47 at +27°C	Satisfactory
A2	410	330	26	50	47 at 0°C	Satisfactory
A3	510	350	26	50	47 at -20°C	Satisfactory
A4	510	350	26	50	47 at -20°C	Satisfactory
A5	410	330	26	50	47J at -20°C	Satisfactory
B1	510	350	26	50	47J at -20°C	Satisfactory
B2	510	350	26	50	47J at -20°C	Satisfactory
B3	540	390	24	45	25J at -46°C	-
B4	540	390	24	45	25J at -46°C	-
C1	590	450	20	40	27J at -20°C	-
C2	590	450	20	40	27J at -20°C	-
D	490	350	22	40	50J at -20°C	-
E1	410	330	26	50	47J at 0°C	-
E2	550	460	24	45	27J at -20°C	-

Note: Tolerances in limiting values as given in respective IS/AWS are applicable.

Table-6

(Cl.6.2.2)

**TABLE OF BASE MATERIAL REQUIREMENT AND MINIMUM
VALUES OF DIFFERENT MECHANICAL PROPERTIES FOR
ELECTRODES OF IRS CLASS 'K' AND 'L'**

IRS Class	IS/AWS Specification	Electrode Classification	Base material specification	UTS in kg/mm ²	Bend test Angle of bend
K	IS: 8666-91	E-Cu Sn-A	IS 7814 -85 Gr.I	24.61	Satisfactory at 90 ⁰
L	AWS A5.3	Al-43	ASTM B 209 Gr. 3003	9.80	Satisfactory at 180 ⁰

Note: Tolerances in limiting values as given in respective IS/AWS are not applicable.

6.2.3 **Usability Test:** Usability test shall be carried out for F and G class of electrodes. The procedure of testing and acceptance criteria has been given in **Appendix- C**.

6.2.4 **Radiography Test:** Radiography of butt weld test piece shall be minimum of IIW Blue Standard.

6.2.5 **Hydrogen Content:** Hydrogen content shall be determined by Mercury apparatus method.

6.2.6 **Deposition Efficiency:** Deposition efficiency of an electrode shall be determined by Core wire method.

$$\text{Deposition Efficiency \%} = \frac{\text{Wt. of weld deposit of 3 electrodes}}{\text{Wt. of 3 core wires - Wt. of 3 stub ends}} \times 100$$

Wt. of 3 core wires - Wt. of 3 stub ends

6.2.7 **Corrosion Resistance:** Corrosion resistance test shall be carried out for D class of electrodes. Procedure of testing and acceptance criteria has been given in **Appendix- D**.

6.2.8 **Hardness Survey:** Hardness survey shall be carried out for H3 and H4 classes of electrodes. Procedure of weld pad preparation, testing and acceptance criteria have been given in **Appendix- B for H3 and Appendix –F for H4**.

6.2.9 **Macro Examination:** Macro examination test shall be carried out for H3 and H4 classes of electrodes. Procedure of weld pad preparation, testing and acceptance criteria have been given in **Appendix- B for H3 and Appendix –F for H4**.

6.2.10 Fillet Weld Test: Fillet weld test will be carried out for D class and M series of electrodes. The completed fillet weld test specimen shall be examined visually and the weld shall be free of cracks. The specimen shall be reasonably free of undercut, overlap, slag inclusion and surface porosity. Dimensional measurements and Macro examination shall be carried out on polished and etched transverse section. The transverse section shall have adequate penetration without any crack and shall reasonably be free from other welding defects .The dimensional requirement of fillet weld test is given in **Table –7**.

6.2.11 Chemical composition - The chemical composition requirement of low & medium alloy ferrous electrodes, high alloy ferrous electrodes and non-ferrous electrodes & Gas Welding Rods have been given in **Table 8, 9 &10** respectively. Procedure of weld pad preparation and sample collection for chemical analysis has been given in **Appendix B**.

TABLE 7
DIMENSIONAL REQUIREMENTS FOR FILLET WELDS

Size of Fillet Weld (mm)	For IRS class D		For IRS M series	
	Maximum convexity (mm)	Maximum diff. Between leg lengths (mm)	Maximum convexity (mm)	Maximum diff. Between leg lengths (mm)
3.15	1.1	1.0	1.2	1.5
4.0	1.2	1.2	1.3	1.5
5.0	1.5	1.5	1.4	1.5
5.6	1.6	2.0	1.5	1.5
6.3	1.8	2.5	1.6	1.5
7.0	1.8	2.8	1.7	1.5
8.0	2.0	3.15	1.8	1.5
9.0	2.0	3.6	1.9	1.5
10.0	2.0	4.0	2.0	1.5

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TABLE –8 (Cl. 6.2.11)
CHEMICAL COMPOSITION REQUIREMENTS FOR WELD DEPOSIT
OF LOW & MEDIUM ALLOY FERROUS ELECTRODES

IRS Class	C	Mn	Si	Ni	Cr	Mo	S	P	Cu	V
*(A3,A4,B1,B2)	0.12	1.6	0.75	0.30	0.20	0.30	0.035	0.035	-	0.08
B3	0.10	1.20	0.80	2.0 - 2.75	-	-	0.030	0.030	-	-
B4	-do-	-do-	-do-	-do-	-	-	-do-	-do-	-	-
C1	0.10	1.25 - 1.75	0.80	-	-	0.25 - 0.45	0.030	0.030	-	-
C2	-do-	-do-	-do-	-	-	-do-	-do-	-do-	-	-
D	0.12	0.50-1.30	0.35-0.80	0.40-0.80	0.45-0.70	-	0.040	0.030	0.30-0.75	-
E2	0.10	-	-	0.50(Min)	-	-	0.030	0.030	-	-
H4A	0.30-0.60	0.60-1.00	0.50	-	5.0-9.0	0.50	0.030	0.030	-	0.50
H4B	0.20	3.00	1.50	-	5.0	1.50	0.030	0.030	-	-

Note: 1) Single values are maximum except otherwise stated.

2) Tolerances in limiting values as given in respective IS/AWS are applicable.

3) The space where – mark is given against a particular element, the same may be present in small quantity in the core wire/weld metal if felt necessary by the manufacturer. But presence of the element should not adversely affect the end property of the weld.

* Combined limit for Mn+Ni+Cr+Mo+V =1.75 Max

TABLE– 9 **(Cl. 6.2.11)**
CHEMICAL COMPOSITION REQUIREMENTS FOR WELD DEPOSIT OF
HIGH ALLOY FERROUS ELECTRODES

IRS Class	%Chemical Composition							
	C	Cr	Ni	Mn	Mo	Si	S	P
M1	0.08	18.0 – 21.0	8.0 – 11.0	2.50	0.50	0.90	0.030	0.040
M2	0.04	18.0 – 21.0	8.0 – 11.0	2.50	0.50	0.90	0.030	0.040
M3	0.08	17.0 – 20.0	11.0 – 14.0	2.50	2.0 – 2.5	0.90	0.030	0.040
M4	0.04	22.0 – 26.0	11.0 - 15.0	2.50	0.50	0.90	0.030	0.040
M5	0.20	17.0 - 20.0	7.0 – 10.0	5.0 – 8.0	0.50	0.90	0.030	0.040
M6	0.20	24.0-28.0	18.0-22.0	2.50	0.50	0.75	0.030	0.030
M7	0.15	28.0-32.0	8.0-12.0	2.50	0.50	0.90	0.030	0.040

Note: 1) Single values are maximum except otherwise stated.

2) Tolerances in limiting values as given in respective IS/AWS are applicable.

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TABLE –10

(Cl. 6.2.11)

**CHEMICAL COMPOSITION REQUIREMENTS FOR CORE WIRE OF NON-FERROUS
ELECTRODES AND GAS WELDING RODS**

IRS Class	%Chemical Composition														
	C	Al	Pb	Sn	Ni	Cu	Mn	Cr	Zn	Si	S	P	Fe	Ti	Total of other element
G	2.0	-	-	-	45.0 - 60.0	2.50	1.0	-	-	4.0	0.030	-	R	-	1.0
K	-	0.01	0.02	4.0 - 6.0	-	-	-	-	-	-	-	0.10 - 0.35	-	-	0.50
L	-	R	-	-	-	0.30	0.05	-	0.10	4.50 – 6.0	-	-	-	0.20	0.15
GWR Cl. I	0.10	-	-	-	0.25	-	0.60	-	-	-	0.040	0.040	-	-	-
GWR Cl. II	0.10 - 0.20	-	-	-	-	-	1.0 - 1.60	-	-	0.10 – 0.35	0.040	0.040	-	-	-
GWR Cl. III	0.25 - 0.30	-	-	-	0.25	-	1.30 -1.60	0.25	-	0.30 - 0.50	0.040	0.040	-	-	-
GWR Cl. IV		0.03	0.03	0.50	-	57.0 – 63.0	-	-	R	0.20.-0.50	-	-	-	-	-

Note:

- 1) Single values are maximum , except otherwise stated.
- 2) Tolerance in limiting values as given in respective IS/AWS are applicable.
- 3) The space where – mark is given against a particular element, the same may be present in small quantity in the core wire/weld metal if felt necessary by the manufacturer. But presence of the element should not affect adversely the end property of the weld.
- 4) R -indicates remaining percentage

7. **Storage:**

The electrode shall be stored in a dry room to minimise ingress of moisture. The roof, floor and walls shall be made of damp proof concrete/brick. The storeroom shall not be used as storage place for grease, oil or other chemicals, which may affect the performance of electrodes adversely. Preferably a separate room should be allotted. The storing system shall be **First in First out (FIFO)** to prevent undue storage.

8. **Shelf Life:**

The shelf life of the electrodes shall be 12 months from the date of receipt in Stores or 18 months from the date of manufacture whichever is more.

9. **Sampling plan for inspection of lot/s**

No. of packets (size wise) as lot size	No. of packets to be sampled
Up to 200	02
201-500	03
501-1000	05
1001-2000	07
2001 and above	10

10. **Test:**

Preparation of test pieces and testing shall be done as per relevant IS/AWS specification unless otherwise stated.

11. **Test for Bulk inspection:**

All the requirements as given in Cl. 6 shall be applicable, only the tests are to be conducted on the size/s given in the Purchase Order.

12. **Retest:**

Where any test specimen fails to satisfy the requirement of a particular test, twice the no. of test specimens for that test shall be prepared using consumable from the same batch wherever possible and subjected to the test in which failure occurred. The consumable shall not be accepted as having passed that test unless all the test results on the additional specimens are satisfactory.

List of Appendices and Tables of IRS-M-28-11

Appendix - A (Clause 6.2.1)	-	Guideline for Running Performance Test and Storage Stability Test.
Appendix - B (clause 6.2.11, 6.2.9 & 6.2.8)	-	Method of preparation of test pads for Chemical analysis, Hardness Survey, Macro test and acceptance criteria.
Appendix - C (clause 6.2.3)	-	Method of Usability Test.
Appendix - D (clause 6.2.7)	-	Method of preparation of test piece for corrosion resistance test and acceptance criteria (For D class of electrode).
Appendix - E		Safety considerations in welding
Appendix - F (Clause 6.2		Method of preparation of test pad for macro test, hardness survey and chemical analysis and acceptance criteria(for H4 series of electrodes)

Table - 1 (Cl. 3.1) - Classification of Electrodes as per their purpose of use along with IS Specification and coding thereof.

Table - 2 (Cl. 3.3) - Classification of Gas Welding Rods as per their purpose of use along with IS Codification.

Table - 3 (Cl. 6.2) - Acceptance criteria for A to E class of electrodes.

Table - 4 (Cl. 6.2) - Acceptance criteria for F to N class of electrodes.

Table - 5 (Cl. 6.2.2) - Minimum acceptable values of different mechanical properties for A to E class of electrodes.

Table - 6 (Cl. 6.2.2) - Base material requirement and acceptable values of mechanical properties of K and L Class of electrodes.

Table – 7 (Cl. 6.2.10) - Dimensional requirement for fillet welds.

Table - 8 (Cl. 6.2.11) - Chemical composition requirements for weld deposit of low & medium alloy ferrous electrodes.

.Table - 9 (Cl. 6.2.11) - Chemical composition requirements for weld deposit of high alloy ferrous electrodes.

Table - 10 (Cl. 6.2.11) - Chemical composition requirements for core wire of non-ferrous electrodes and gas welding rods.

Table – 11 (App – C)- Minimum dimension of test piece and electrode for usability test.

APPENDIX 'A'

(Cl. 6.2.1)

**REQUIREMENTS FOR RUNNING PERFORMANCE TEST AND
ACCELERATED STORAGE STABILITY TEST.**

A 1 Running Performance: Running performance test shall be done by deploying the welder approved as per IS: 7310 Part 1 and IS: 7318 Part 1 and performance test shall be applicable for all class of electrodes. Following criteria shall be checked

A 1.1 General:

- a) Packing condition: Shall be as per clause 5.
- b) Physical condition of electrode (core wire and flux): Coating shall not be damaged / cracked. Core wire shall not be rusted.
- c) Size and number of electrode in a packet shall be indicated : Diameter of core wire & length shall be within permissible limits
- d) Coating factor (Ratio of dia. of core wire and dia. of electrode in flux coated area): shall be as stipulated in respective IRS class.
- e) Size of stub end and quality of end brushing: as per related IS/AWS

A 1.2 Current condition: Electrodes (except N series) for all sizes offered shall be operated in the current range (both minimum and maximum) as recommended by the manufacturer. The minimum voltage as recommended by respective IS/AWS code shall be taken. In case IS/AWS code is not applicable, minimum voltage as recommended by the manufacturer shall be considered. In lower current range, the electrode shall run smoothly without any arc breaking and in higher current range the electrode shall not become red hot upto minimum 50mm beyond stub end.

A 1.3 Performance test: Electrode (except N series) shall be operated at ± 20 Amp of the middle of the current range given. Following parameters shall be checked:

- a) Ease of arc striking : The electrode should produce arc easily.
- b) Arc stability : The arc must be stable & should not break during arcing.
- c) Arc length : Short/Touch type/Medium/Long
- d) Spatter quality & quantity: The spatter shall be less. & soft.
- e) Smoke quality & quantity: The smoke shall be normal & arc should be visible.
- f) Viscosity & controllability of slag: should properly covered the weld beads
- g) Colour of slag: Black/Brown/Grey/Other.

- h) Slag detachability: The slag should be easily removed by chiselling.
- i) Ripple of weld bead: Smooth & evenly rippled.
- j) Convexity of weld bead : Flat to convex/concave.
- k) Tendency to undercut: No tendency to undercut.
- l) Crack, porosity etc. : Free from cracks & porosity & other defects .

There shall not be any adverse remark in any of the items indicated above.

- A 1.4 **Positional welding:** Upto 4.00mm dia. electrode shall be operated at all the welding positions as per IS/AWS code. The appearance and quality of weld shall be satisfactory.
- A 1.5 **Cutting & Gouging:** This shall be applicable for N series of electrodes only. A cutting electrode shall be able to cut through smoothly using the welding parameters recommended by the manufacturer. The plate can be mild steels, low alloy steels, stainless steels, austenitic manganese steels, cast iron, cast steel & non-ferrous alloys such as Nickel alloys, Al, Cu, Bronzes etc. A gouging electrode shall be able to gouge easily the plates of material as mentioned above. However, testing of N3 class of electrode shall be limited to ferrous items only.
- A 1.6 **Any other adversity:** There shall not be any other adverse remark on the performance of the electrode.
- A1.7 The precautions to be taken during welding are given in **Appendix-E**. These precautions must be followed during welding operation.
- A 2 **Accelerated Storage Stability Test:** This test is applicable for all classes of electrodes.
- A 2.1 **Test:** Ten numbers of electrode shall be kept in a humidity chamber maintained at 48^o C with Relative Humidity(RH) 90% min. for eight hours. After putting off the system, the electrodes shall be left in the humidity chamber for another 16 hours. After this period, the electrodes shall be taken out from the chamber and examined visually.
- A 2.2 **Acceptance criteria:** At least eight electrodes out of ten shall not exhibit any:
 - a) Peeling off of flux coating.
 - b) Cracking of flux coating.
 - c) Loss of texture of flux.
 - d) Rusting of core wire inside flux coating.

For high deposition electrodes, deposition efficiency shall not fall below the minimum stipulated value of 110% when tested with the electrode found acceptable as per criteria given above.

APPENDIX 'B' (Clauses 6.2)

METHOD OF PREPARATION OF TEST PAD FOR MACRO TEST, HARDNESS SURVEY AND CHEMICAL ANALYSIS AND ACCEPTANCE CRITERIA

(For A3,A4,B1,B2, B3, B4, C1, C2, D, E2,G class and H3 & M series classes of Electrodes)

B .1 **Preparation of Test weld Pad:**

B 1.1 **Material:** The parent metal for plates used in preparing test pieces shall be any grade of IS: 2062-2006

B 1.2 **Welding:** Test pad shall be prepared as shown in fig.1 using the welding parameters as specified by the manufacturers. The weld metal shall be deposited in flat position, using 3.15 mm dia and either 4.0 or 5.0 mm dia electrodes at the discretion of the approving authority. The deposit shall be at least 25mm thick.

B .2 **Macro and Micro examination:**

B2.1 **Macro examination:** The surface of pad shall show no crack or other welding defects on macro examination with suitable magnification /DPT/MPT. The pad shall be sectioned and etched suitably to examine the cross section and interface. The cross section shall be free of any welding defect with proper fusion and bonding at interface.

B2.2 **Micro examinations:** The micro examination test shall be carried out for H3 series of electrodes on separate parent metal by depositing around 10 mm layers.

B 3 **Hardness survey:**

B 3.1 Hardness test shall be conducted at five places, one at the centre and four corners at a distance of $D/4$, D being the diagonal of the pad as shown in **Fig. 1**. Hardness number obtained shall be recorded.

B 3.2 The hardness requirement of different hard facing electrodes shall be as given in **Table-4**.

B 4 **Sampling for Chemical analysis:**

B 4.1 Sufficient sample shall be taken from the test weld pad by an appropriate means (by drilling or shaping). Post heat treatment may be carried out to soften the test pad for easy removal of metal. Metal for the analysis purpose shall not be taken closer than 5 mm from the base metal. No oil or other lubricant shall be used while removing the sample.

- B 4.2 Wet analysis for different elements shall be carried out in accordance with IS: 228-2003.
- B 4.3 Spectrometric analysis may also be carried out on solid and smooth surface of the pad after removing about 5 mm from top on at least 3 spots. The average of 3 readings shall be taken as the value for a particular element.
- B 4.4 In case of any controversy in the spectrometric analysis, wet analysis shall be considered as referee method.
- B 4.5 The chemical composition of the weldment shall conform to the range given in **Table – 8 & 9.**

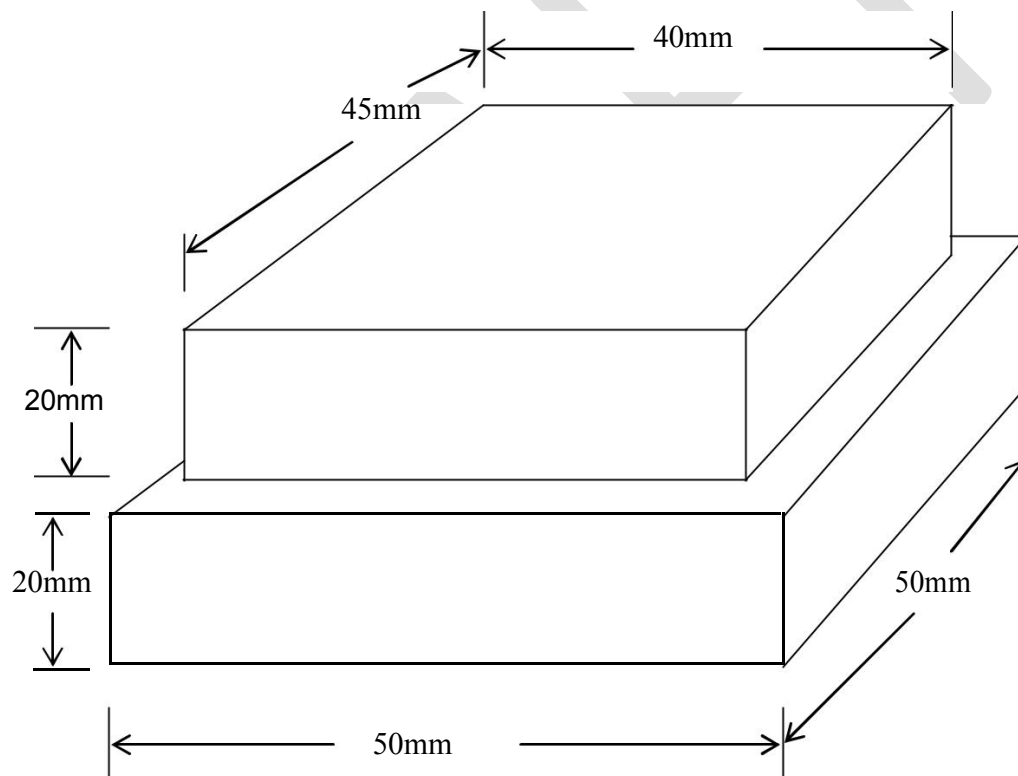


Fig: 1. Dimension of Weld Pad

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APPENDIX 'C' (Clause 6.2)

METHOD OF USABILITY TEST AND ACCEPTANCE CRITERIA (For F & G class of Electrodes)

C 1 Details of test piece and welding:

C 1.1 **Material:** Test plates shall be grey iron casting conforming to Grade FG-200 of IS: 210-93 or its equivalent and shall be reasonably free from porosity and other harmful defects. The groove shall be prepared as per Fig. 2 by machining or grinding.

C 1.2 **Test piece dimension:** The test plates shall conform to the dimensional requirements shown in Fig. 2. Table 11 below gives the diameter of electrodes and the corresponding dimensions of 'Width (W)', 'Depth (D)', 'Thickness (T)' and the minimum number of layers required for the preparation of the test pieces. Two test pieces shall be prepared using 3.15 & 5.0 mm size electrodes.

TABLE 11

MINIMUM DIMENSION OF TEST PIECE AND ELECTRODE

Dia. of electrode	'W' in mm	'D' in mm	'T' in mm	Number of layers
2.5	4.0	3.50	13.0	2 or 3
3.15	5.0	4.0	13.0	2 or 3
4.0	6.0	5.0	13.0	2 or 3
5.0	8.0	6.0	25.0	2 or 3
6.3	10.0	8.0	25.0	2 or 3

C 1.3 **Welding & Machining:** The groove in the test plate shall be completely welded in flat position. The welding parameters to be used shall be as recommended by the manufacturer.

The weld and plate shall be machined or ground 1 to 2 mm below the surface of the plate for visual examination.

C 2 Acceptance criteria:

C 2.1 **Cracks & Pores:** Weld area shall be reasonably free from cracks, and porosity not exceeding six pores per 10 Sq. cm area, with no pores greater than 1.5mm in diameter.

C 2.2 **Hardness:** Brinell hardness survey shall be carried out on the weld deposit. The hardness number shall be within 175 to 200 BHN for class G electrode.

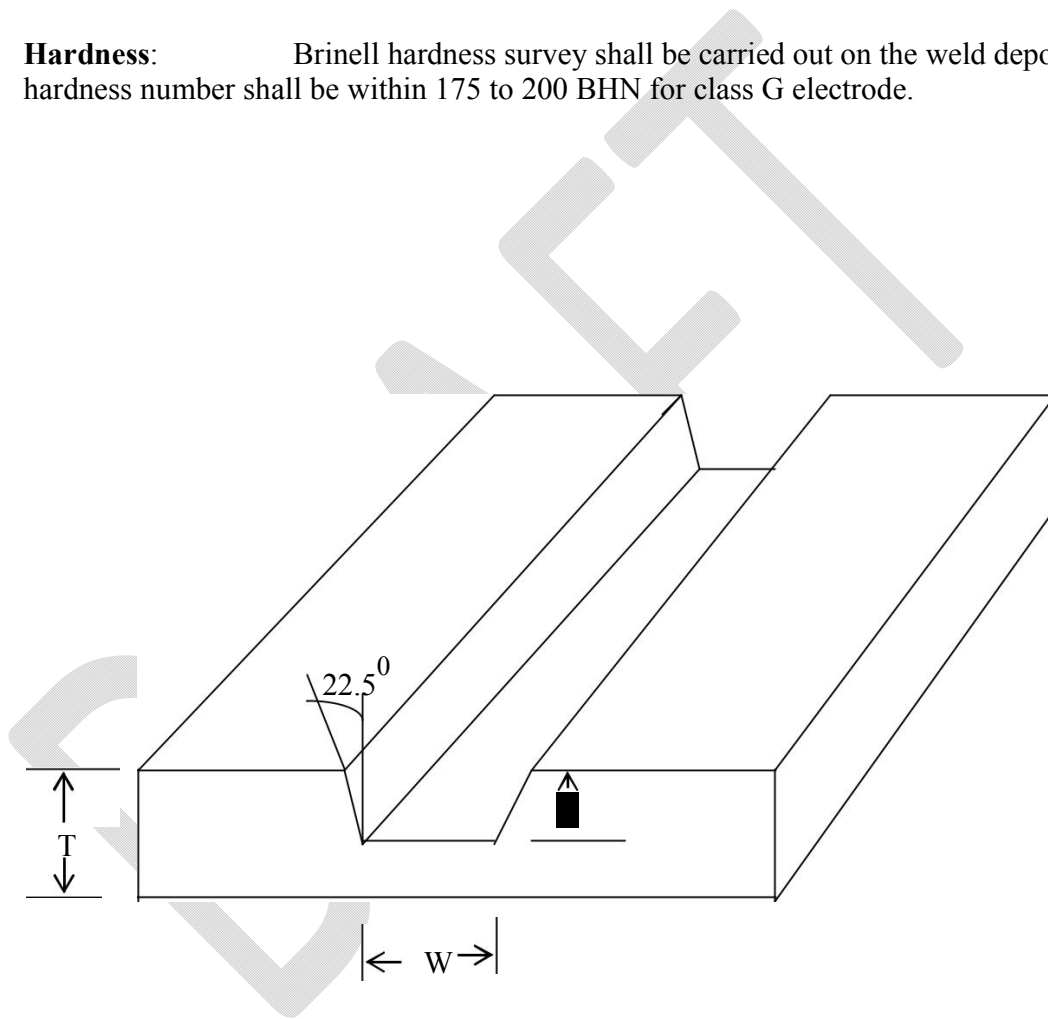


Fig: 2. Dimension of Test Piece

APPENDIX 'D'

(Clause 6.2)

**METHOD OF PREPARATION OF CORROSION RESISTANCE TEST
PIECE AND ACCEPTANCE CRITERIA****(For D class of electrode)****D 1 Preparation of Corrosion Resistance Test Assembly:**

D 1.1 **Material:-** Parent metal shall conform to IRS M-41, IRS M-42 or their equivalent. D

1.2 **Dimensions:** The dimensions of plates shall be as given below:

Length	-	150mm \pm 10mm
Breadth	-	75mm \pm 10mm
Thickness	-	10mm \pm 2mm
Edge Angle	-	10° \pm 1°

D 2 Pre-setting and Welding:

D 2.1 The plates shall be tacked together with a root gap of about 2-3 mm. The faces to be welded shall be free from dust, dirt, grease, oil or any other foreign material.

D 2.2 The assembly shall be welded in flat position using 4.0mm size of electrode.

D 2.3 The temperature of weld assembly shall be kept between 110°C-180°C. For this, inter pass time gap, if necessary shall be maintained.

D 2.4 Each run shall be properly de-slagged before putting another run on or adjacent to previous run.

D 2.5 The welding parameters shall be kept within the range as recommended by the manufacturer.

D 2.6 Two such test assemblies shall be prepared as shown in **fig. 3**.

D 3 Preparation of Test Pieces:

- D 3.1 A square panel of 100mm x 100mm x 10mm shall be removed from centre as shown in **fig. 4**.
- D 3.2 A test panel of 100mm x 100mm x 6mm shall be prepared as shown in **fig. 5** by shaping.
- D 3.3 The whole test panel shall be thoroughly polished.
- D 3.4 Two such panels shall be prepared from two test assemblies.
- D 3.5 One blank panel of same dimensions shall be prepared using same material of parent plates.

D 4 Testing:

- D 4.1 Two test panels with weld bead at middle along with one blank panel shall be subjected to corrosion test at a temperature of 42°C to 48°C at relative humidity 100% as per section 1 of IS: 101-88, Pt-6. Condition of the weld and parent metal surfaces shall be examined after a period of seven days exposure as follows:

1st 24 hours	-	The weld assembly shall be exposed as indicated in Cl. D 4.1.
2nd 24 hours	-	Air-dried at ambient temperature.
3rd to 7th day	-	The weld assembly shall be exposed as indicated in Cl. D 4.1.

D 5 Acceptance Criteria:

- D 5.1 The number of corrosion spots per 5 Sq. cm of the unwelded panel and the parent metal of the welded panel shall not vary by more than one. The severity of corrosion shall not be significantly different.
- D 5.2 The number of corrosion spots in the HAZ or weld metal shall not be more than that of unwelded panel or parent metals whichever is more.
- D 5.3 The severity of corrosion in parent metal and HAZ shall not be significantly more than that of parent metal of unwelded panel.
- D 5.4 The electrode shall be considered satisfactory in case all the 3 clauses mentioned above are fulfilled.
- D 5.5 The test shall be discarded and repeat test is to be carried out in case clause D 5.1 is not fulfilled.
- D 5.6 The electrode shall be considered unsatisfactory only if clause D 5.1 is fulfilled but either clause D 5.2 or clause D 5.3 is not fulfilled and retest shall be carried out.

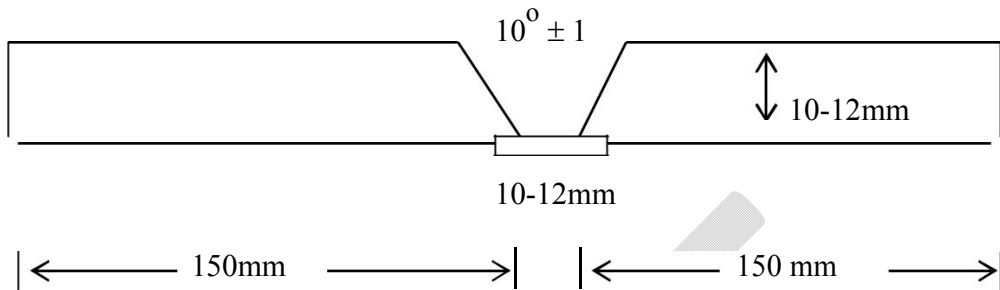


Fig. 3. Presetting of plates & back strip before welding.

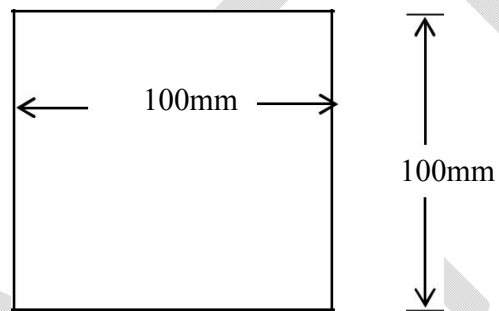


Fig. 4. Middle part of the assembly for making the test panel.

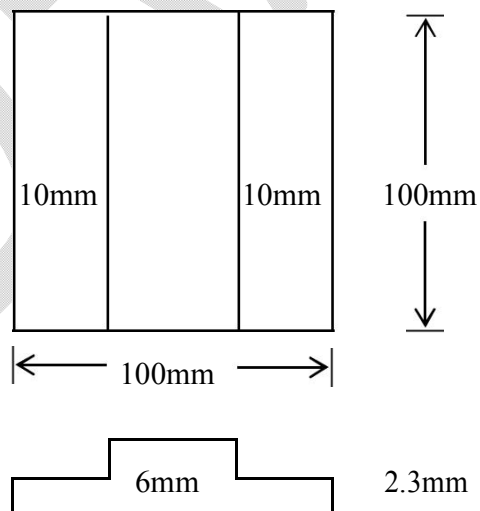


Fig. 5 Plan & Elevation of the test panel.

APPENDIX-E**SAFETY CONSIDERATIONS IN WELDING****E1 Burn Protection**

E1.1 Molten metal, sparks, slag & hot work surfaces are produced by welding cutting & allied processes. These can cause burns.

E1.2 To avoid burns worker should wear protective cloths made of fire resistance material.

E1.3 Pant cuffs, open pockets or other places on clothing that can catch & retain molten metal should not be worn.

E1.4 High top shoes or leather leggings & fire resistant gloves should be worn.

E1.5 Helmet or hand shields that provide protection for face, neck & ear, & a head covering to protect the head should be used.

E1.6 The clothing should be kept free of grease & oil.

E1.7 Wear insulated gloves.

E2 Electrical Hazardous

E2.1 All electrical instrument and work pieces should be grounded.

E2.2 To prevent shock, the work area, equipment & clothing should be kept dry all the times.

E2.3 Welder should wear dry gloves & rubber sole shoes.

E2.4 Cables & connection should be kept in good condition.

E2.5 Correct cable size should be used to avoid over loading & subsequent failure of cable.

E2.6 All electrical connections should be tight, clean & dry.

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E3 Fumes and gases

E3.1 Fumes are solid particles which originates from welding filler metals and fluxes, the base metal and any coating presents in base metal.

E3.2 Sufficient ventilation & exhausts should be used to keep fumes and gases away from breathing zone when welding is performed in the confined spaces.

E3.3 Use auto- darkening helmets.

E3.4 Follow the recommendations of manufacturers (if any) in this regard.

E4 Radiation

E4.1 Welding, Cutting and allied operations may produce radiant energy.

E4.2 One should not look at welding arc except through welding filter plates.

E4.3 Exposed Skin should be protected with adequate gloves & clothing.

APPENDIX 'F'

(Clauses 6.2)

**METHOD OF PREPARATION OF TEST PAD FOR MACRO TEST,
HARDNESS SURVEY AND CHEMICAL ANALYSIS AND ACCEPTANCE
CRITERIA****(For H4 series of Electrodes)****F 1 Preparation of Test weld Pad:**

F 1.1 **Material:** The parent metal for plates used in preparing test pieces shall be any grade of IS: 2062-2009

F 1.2 **Welding:** The weld shall be deposited in flat position in longitudinal beads. The deposit shall be of about 15mm thickness which after machining will have deposited thickness of 12mm as shown in figure 7 for chemical analysis. The pad for macro/DPT/MPT and hardness testing shall also be prepared by depositing longitudinal beads to obtained deposited thickness of about 15mm which after machining will have deposited thickness of 10mm as shown in figure 6. The pad shall be prepared by using 3.15mm dia and, either 4.0mm or 5.0mm dia electrodes.

F 2 Macro examination & DP test:

The surface of weldment shall show no crack or other welding defects on dye penetrant/magnetic particle test. The weldment pad shall be sectioned across the direction of welding and etched suitably to examine the cross section and interface. The sectioned surface shall be free of any welding defects within HAZ, fusion line and weld metal.

F 3 Hardness survey:

F 3.1 Hardness test shall be conducted at five places, one at the centre and four corners at a distance of $D/4$, where D being the diagonal of the pad as shown in **Fig. 6**. Hardness number obtained shall be recorded.

F 3.2 The hardness requirement of different hard facing electrodes shall be as given in **Table-4**.

F 4 Sampling for Chemical analysis:

F 4.1 Sufficient samples shall be taken from the test weld pad by an appropriate means (drilling or shaping). Post heat treatment may be carried out to soften the test pad for easy removal of metal. Metal for the analysis purpose shall not be taken closer than 5 mm from the base metal. No oil or other lubricant shall be used while removing the sample.

F 4.2 Wet analysis for different elements shall be carried out in accordance with IS: 228-2003.

F 4.3 Spectrometric analysis may also be carried out on solid and smooth surface of the pad after removing about 5 mm from top on at least on 3 spots. The average of 3 readings shall be taken as the value for a particular element.

F 4.4 In case of any controversy in the spectrometric analysis, wet analysis shall be considered as referee method.

F 4.5 The chemical composition of the weldment shall conform to the range given in **Table – 8 & 9.**

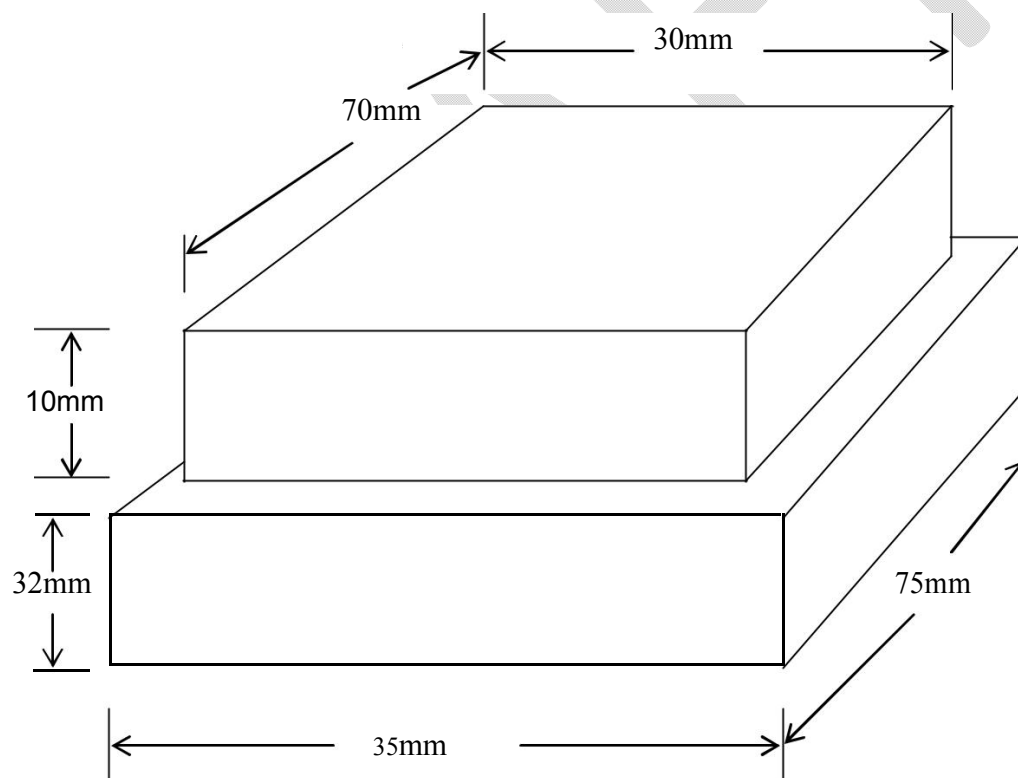


Fig: 6. Dimension of Weld Pad for hardness and macro examination

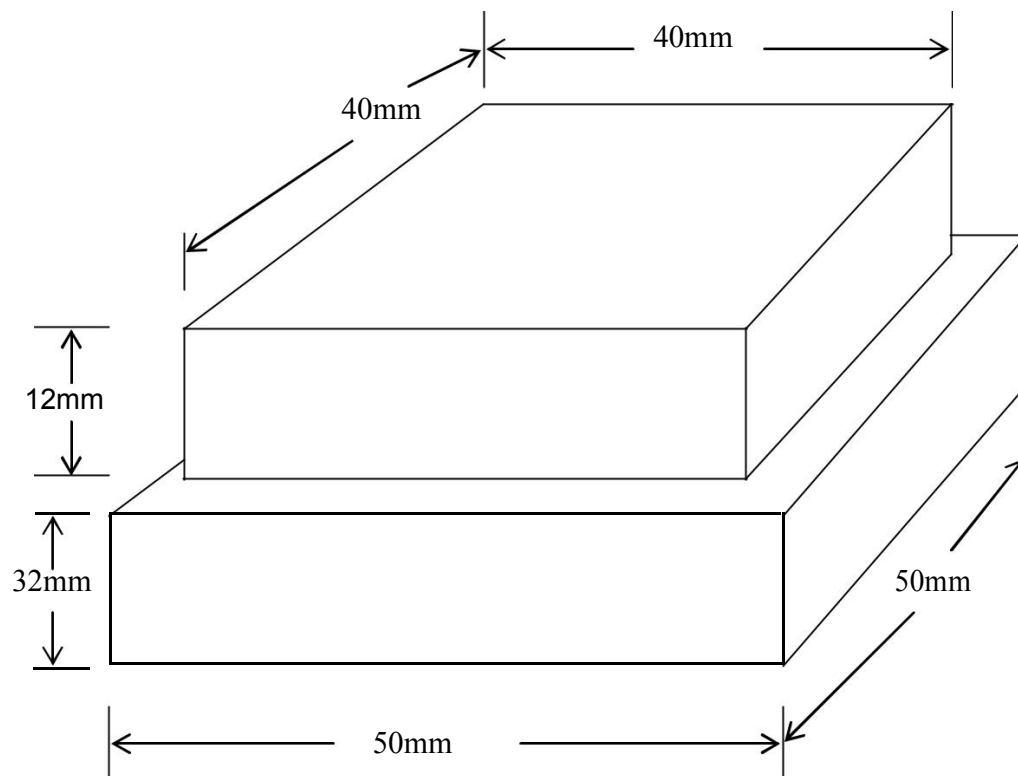


Fig: 7. Dimension of Weld Pad for Chemical analysis