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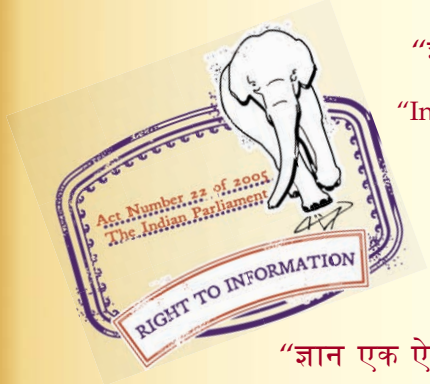
IS 6560 (1996): Molybdenum and chromium-molybdenum low alloy steel welding rods and bare electrodes for gas shielded arc welding [MTD 11: Welding General]



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"Knowledge is such a treasure which cannot be stolen"

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IS 6560 : 1996
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भारतीय मानक

गैस परिरक्षित आर्क वैल्डिंग के लिए मोलिबिडनम एवं क्रोमियम-मोलिबिडनम अल्प मिश्रधातु इस्ताप की वेल्डिंग छड़ें और अनावृत इलेक्ट्रोड – विशिष्टि

(पहला पुनरीक्षण)

Indian Standard

MOLYBDENUM AND CHROMIUM-MOLYBDENUM LOW ALLOY STEEL WELDING RODS AND BARE ELECTRODES FOR GAS SHIELDED ARC WELDING — SPECIFICATION

(First Revision)

ICS 25.160.20; 77.140.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 1996

Price Group 5

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indain Standards, after the draft finalized by the Welding General Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard is one of the series of standards covering comprehensively the requirements for the solid filler rods and wires for gas shielded arc welding, and covers molybdenum and chromium-molybdenum low alloy steels. The other standards, published so far in this series, cover the filler rods and wires for inert gas welding of the following:

a) Structural steels,

b) Corrosion and heat-resisting chromium-nickel steel,

c) Copper and copper alloy,

d) Aluminium and aluminium alloy and magnesium alloy, and

e) Nickel and nickel alloy.

This standard was first published in 1972. While reviewing the standard in the light of experience gained during these years, the Committee decided to revise it to bring in line with the present manufacturing and trade practices being followed by the Indian industry.

In this revision, following modifications have been made:

a) Conditions of rods and wires have been modified by specifying the tensile properties and sizes of cast and helix.

b) Classification has been given on the basis of chemical composition and mechanical properties of the weld deposits and the type of shielding gas.

c) Sample preparation for all weld tests for tensile and impact has been included.

In the preparation of this revised standard, assistance has also been derived from the following overseas standards:

ISO 544 : 1980 Filler material for manual welding size requirements issued by the International Organization for Standardization (ISO).

ISO 864 : 1988 Solid and tubular cored wires which deposit carbon and carbon manganese steel — Dimensions of wires, spools, rims and coils issued by the International Organization for Standardization (ISO).

BS 2901 : Part 1 : 1983 Filler rods and wires for gas-shielded arc welding. Part 1 Ferritic steels issued by the British Standards Institution (BSI).

DIN 8559 : Part 1 : 1984 Filler metals for gas shielded arc welding; wire electrodes, filler wires, solid rods and solid wire for gas shielded arc welding of unalloyed and alloyed steels issued by DIN Germany (DIN).

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, shall be rounded off in accordance with IS 2: 1960 ' Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

MOLYBDENUM AND CHROMIUM-MOLYBDENUM LOW ALLOY STEEL WELDING RODS AND BARE ELECTRODES FOR GAS SHIELDED ARC WELDING — SPECIFICATION

(First Revision)

1 SCOPE

1.1 This standard prescribes the requirements of solid filler rods and wires for welding. It covers molybdenum and chromium molybdenum low alloy steel rods and wires for use in inert-gas tungsten arc welding (TIG), gas metal arc welding (MIG) or CO_2 welding processes. The chemical composition and tensile properties of filler rods and wires are also specified.

1.2 This standard also specifies the mechanical properties of the weld deposits.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
228	Methods of chemical analysis of pig iron, cast iron, and plain carbon and low alloys (*revised*)
812 : 1957	Glossary of terms relating to welding and cutting of metals
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
1608 : 1995	Mechanical testing of metals-tensile testing (*second revision*)
1757 : 1988	Methods for charpy impact test (V notch) for metallic material
2002 : 1992	Steels plates for pressure vessels for intermediate and high temperature service including boilers (*second revision*)
2062 : 1992	Steel for general structural purposes (*fourth revision*)
3039 : 1988	Structural steels for construction of hulls of ships (*second revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 812 : 1957 shall apply.

4 SUPPLY OF MATERIAL

General requirements relating to supply of filler rods and wires for inert-gas shielded arc welding shall be as laid down in IS 1387 : 1993.

5 DIMENSIONS AND TOLERANCES

The diameters of rods and wires shall be as specified in Table 1. The tolerances appropriate to the specified diameters are also given.

Table 1 Diameters and Tolerances

Nominal Diameter	Tolerance, mm	
mm	Plus	Minus
0.6	0.01	0.03
0.8	0.01	0.04
0.9	0.01	0.04
1.0	0.01	0.04
1.2	0.01	0.04
1.6	0.01	0.04
1.8	0.01	0.04
2.0	0.01	0.07
2.4	0.01	0.07
2.5	0.01	0.07
2.8	0.01	0.07
3.0	0.01	0.07
3.2	0.01	0.07
4.0	0.01	0.07
5.0	0.01	0.07

6 REELS FOR WIRE

6.1 The size and type of reel (spool, flanged former

and coiled former) on which the particular diameter of wire is to be supplied shall be as agreed to between the purchaser and the manufacturer and shall conform to the appropriate dimensions and tolerances given in Table 2, Table 3 and Table 4. The surfaces of reel coming in contact with wire shall be such as to protect the wire from deterioration.

6.2 The flanges of spools and flanged formers shall be sufficiently robust to avoid deformation during normal usage.

NOTE – The barrel diameter for spools should be as large as possible to permit satisfactory feeding of the wire

7 REELING CONDITIONS

The wire shall be wound on the reel in one continuous length and shall be free from kinks, sharp bends or twists, so that it is free to unwind without restriction. The outer layer of wire shall be not closer than 3 mm to the flange periphery on spools having a flange diameter of 100 mm and not closer than 10 mm to the flange periphery on spools having other flange diameters.

8 LENGTH OF RODS

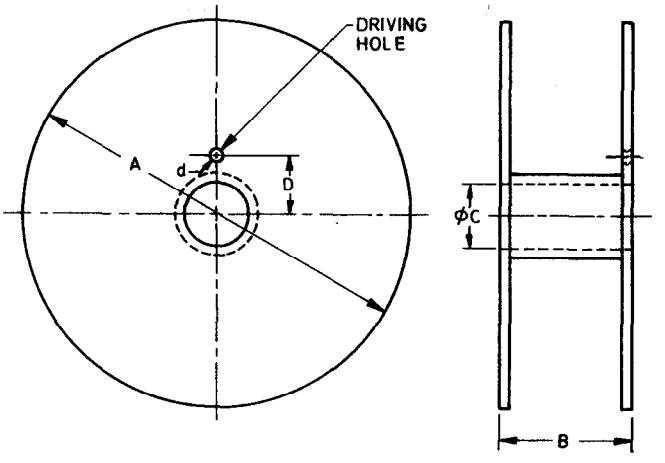
8.1 Rods less than 2.5 mm in diameter shall preferably be supplied in lengths of 500 or 1 000 mm. Rods 2.5 mm and larger in diameter shall preferably be supplied in lengths of 1 000 mm. Lengths other than these two preferred lengths may be supplied by mutual agreement between the purchaser and the supplier.

8.2 Tolerance on Length

Tolerance on each length of rod shall be ±5 mm.

Table 2 Dimensions and Tolerances of Spools

(*Clause* 6.1)



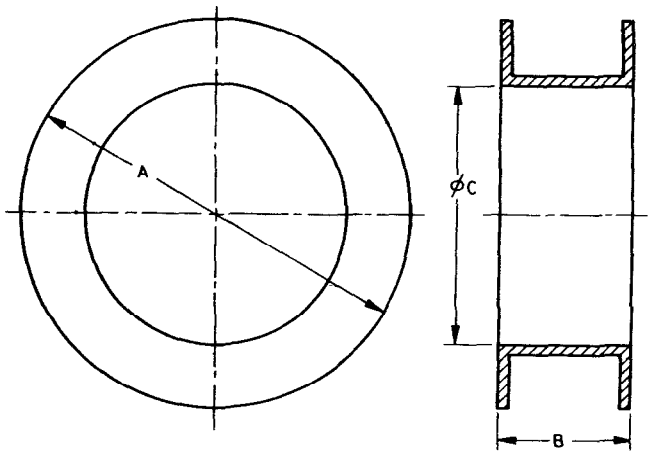
SPOOL

All dimensions in millimetres.

A		*B*		*C*		*D*		*d*	
Diameter	Tolerance	Width	Tolerance	Diameter	Tolerance	Distance Between Axes	Tolerance	Diameter	Tolerance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
100	±2	45	0 −2	16.0	+1.0 0	—	—	—	—
200	±3	55	0 −3	50.5	+2.5 0	44.5	±0.5	10	+1 0
300	±5	103	0 −3	50.5	+2.5 0	44.5	±0.5	10	+1 0
350	±5	103	0 −3	50.5	+2.5 0	44.5	±0.5	10	+1 0
435	±5	103	0 −3	50.5	+2.5 0	44.5	±0.5	10	+1 0

Table 3 Dimensions and Tolerances of Flanged Formers

(*Clause* 6.1)



FLANGED FORMER

All dimensions in millimetres.

A		*B*		*C*	
Diameter	Tolerance	Width	Tolerance	Diameter	Tolerance
300	±5	90	0 −15	200	+10 0
300	±5	120	0 −20	200	+10 0
350	±5	90	0 −15	300	+15 0
350	±5	120	0 −20	300	+15 0
435	±5	90	0 −15	300	+15 0
435	±5	120	0 −20	300	+15 0

NOTE – For dimensions *A* the values given are preferred ones.

9 CONDITIONS OF RODS AND WIRES

9.1 Finish

Filler rods and wires shall have a smooth finish and be free form surface imperfections, corrosion products, grease, excessive oxide or other foreign matter which would adversely affect the properties of the weld or the operation of the welding equipment. If the rods and wires are supplied with a protective copper coating, it shall be a uniform, well-bonded, smooth coating being applied over a thoroughly clean surface. The copper content of the coated rod or wire expressed as a percentage of the rod (or wire) plus the coating shall not exceed 0.35 percent by weight.

9.2 Temper and Helix of Wire

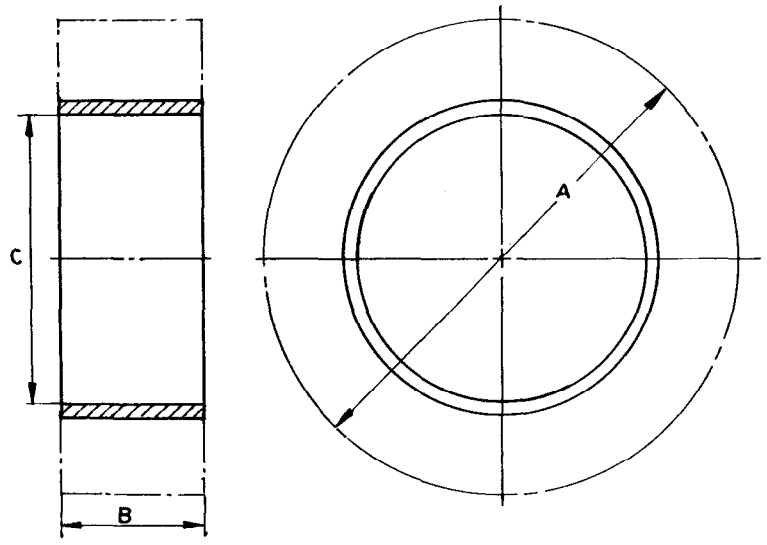
9.2.1 The temper of the filler metals shall be such that they are suitable for uninterrupted feeding on automatic or semi automatic welding equipment. The tensile strength of as manufactured filler materials that are wound on spools of 300 mm and greater in diameter shall be as per Table 5.

9.2.2 *Cast*

The cast of coiled filler metals shall be such as to have imparted a curvature to the filler metal so that a specimen sufficient in length to found one loop or a maximum 3 m when cut from the package and laid in a flat surface without restraint, shall form a circle or portion there of the diameter shown for the cast in Table 6.

Table 4 Dimensions and Tolerances of Coiled Formers

(*Clause* 6.1)



COILED FORMER

All dimensions in millimetres.

A	*B*		*C*	
Diameter	Width	Tolerance	Diameter	Tolerance
300	90	0 −15	200	+10 0
300	120	0 −20	200	+10 0
350	90	0 −15	300	+15 0
350	120	0 −20	300	+15 0
435	90	0 −15	300	+15 0
435	120	0 −20	300	+15 0

NOTE – For dimensions *A* the values given are preferred ones.

9.2.3 *Helix*

The helix of coiled filler metal as executed by the ring used to determine the cast, when placed in flat surface without restraint, shall be such that the maximum distance from any point on the filler metal to flat surface shall not exceed the dimension shown for helix in Table 6.

10 CLASSIFICATION

10.1 The filler rods and wires shall be classified on the basis of their chemical composition and mechanical properties of the weld deposits.

Table 5 Tensile Strength of Filler Rods

(*Clause* 9.2.1)

Wire diameter (mm)	0.6	0.8	0.9	1.0	1.2	1.6-2.0	2.4-3.2
Tensile strength, *Min* (MPa)	1 100	1 100	1 000	950	900	700	600

Table 6 Dimensions of Cast and Helix

(*Clauses* 9.2.2 *and* 9.2.3)

Type of Package	Standard Size mm	Cast mm	Maximum Helix, mm
100 mm spool	1.2 and less	100-130	13
All except 100 mm spool	0.8 and less	305	25
	0.9 and larger	380	25

10.2 In a classification, for example, SLA-5-M 504 where SLA-5 indicate chemical composition of the filler metal, M indicates that it is mixed gas, 50 indicates tensile strength of minimum 500 MPa and 4 indicates the impact values of 27 joules at minus 30°C.

11 CHEMICAL COMPOSITION

11.1 The chemical composition of filler rods and wires when analyzed in accordance with the relevant part of IS 228 shall be as given in Table 7.

11.2 The manufacturer shall carry out analysis from each cast of steel and when required by the purchaser, supply a certified cast analysis of a sample of steel from each cast.

12 MECHANICAL PROPERTY REQUIREMENT

12.1 Symbol Indicating Tensile Strength and Elongation

Symbol	*Yield Strength*, Min	*Tensile Strength*	*Percent Elongation at Gauge Length* $5.65\sqrt{S_o}$, *Min*
	MPa	MPa	
50	420	500 - 640	20
53	460	530 - 680	18
56	500	560 - 720	16

12.2 Symbol Indicating the Impact Energy

Symbol	*Minimum Impact Energy of 27 Joules (Charpy V Notch at °C Specimen)*
1	+27
2	0
3	−20
4	−30

12.3 Symbol Indicating Shield Gases

Symbol	*Type of Shielding Gas*
R	Reducing gas
I	Inert gas
M	Mixed gas
C	Carbon dioxide
F	Nitrogen hydrogen mixture

13 TEST FOR FILLER METALS (WIRE AND ROD)

The following tests are prescribed to demonstrate the test requirement of the solid filler rods and wires and also the soundness and mechanical properties of the weld deposits.

Table 7 Chemical Composition of Filler Rods and Wires

(*Clause* 11.1)

IS Classification	Chemical Composition, Percent						
	Carbon	Silicon	Manganese	Sulphur	Phosphorus	Chromium	Molybdenum
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SLA-1	0.12	0.20 - 0.90	0.40 - 1.60	0.030	0.030	—	0.45 - 0.65
SLA-2	0.14	0.50 - 0.90	1.60 - 2.10	0.030	0.030	—	0.40 - 0.60
SLA-3	0.12	0.20 - 0.90	0.40 - 1.60	0.030	0.030	1.1 - 1.5	0.45 - 0.65
SLA-4	0.12	0.20 - 0.90	0.40 - 1.60	0.030	0.030	2.0 - 2.7	0.90 - 1.10
SLA-5	0.12	0.20 - 0.90	0.40 - 1.60	0.030	0.030	5.0 - 6.0	0.45 - 0.65

NOTE — Single values shown are maximum percentages except when otherwise stated.

13.1 Chemical Composition

The chemical composition of the filler wire/rods should satisfy the chemical analysis as per Table 7. The chemical analysis shall be made using either 1.2 mm or 1.6 mm diameter filler metal. If the above sizes are not in the manufacturing range, then the size being manufactured nearer to 1.2 mm or 1.6 mm diameter shall be taken for chemical analysis. In case of GTAW, size of 2.4 or 3.2 mm shall be preferred size.

13.2 Soundness Test

Radiographs of the welded test assembly shall reveal no cracks or zone of incomplete fusion. The radiographs should conform to the standard as agreed to between the manufacturer and the purchaser.

13.3 All Weld Metal Mechanical Test

13.3.1 *Weld Metal Assembly*

a) *For gas metal arc welding (GMAW) process*

The test assembly shall be welded in the flat position using 1.2 mm or 1.6 mm diameter filler metal or the size nearer to the above sizes in case of non manufacture of 1.2 mm and 1.6 mm diameter filler metal.

b) *For gas tungsten arc welding (GTAW) process*

Test assembly using GTAW process shall be welded in the flat position using 2.4 mm or 3.2 mm diameter filler metal or the size nearer to the above sizes in case of non-manufacture of the said sizes.

The test assembly shall be prepared and tested as per Annex A.

13.3.2 The ultimate tensile strength, yield stress and percentage elongation shall comply with the values given in **12.1.**

13.3.3 *All Weld Impact Test*

Five charpy V notch test specimen shall be machined from the same test assembly and tested in accordance with the method described in Annex A and shall comply with values given in **12.2.**

13.3.3.1 When computing the average value of the impact properties from the set of the five specimens, the lowest values and highest value obtained shall be discarded. Two of the three remaining values shall be greater than the specified 27 joules. One of them may be lower but shall not be lower than 20 joules.

14 METHOD OF SAMPLING

14.1 The location and the method of sampling shall be as agreed to between the purchaser and the supplier.

14.2 The area to be sampled shall be from the combined transverse sections obtained by bundling the rods or wires after cutting into suitable lengths or by folding. The area shall be cleaned by grinding or pickling. The copper coating shall be removed to expose the base metal before grinding. The sample shall be collected by milling out the areas.

14.2.1 When heat treatment is required to reduce the hardness of the sample piece before machining, the annealing temperature and time shall be kept to a minimum and a suitable discard of the decarburized surface layer shall precede the collection of the sample for analysis. The time and temperature of annealing shall be prescribed by the manufacturer.

15 PACKING

Filler rods and reels of wire shall be suitably packed to guard against damage, combination or deterioration during storage, transit and inspection.

16 MARKING

16.1 Each package of rods and each reel of wire shall be clearly marked with the following information:

a) Classification coding,

b) Name of manufacturer,

c) Trade designation of rods and wire,

d) Size, and

e) Cast number / Batch number.

16.2 STANDARD MARKING

The material may also be marked with the Standard Mark.

16.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clauses* 13.3.1 *and* 13.3.3)

ALL WELD TESTS FOR TENSILE AND IMPACT

A-1 PREPARATION OF TEST PIECES (PREPARATION OF TEST ASSEMBLY FOR ALL WELD TENSILE TEST AND IMPACT TEST)

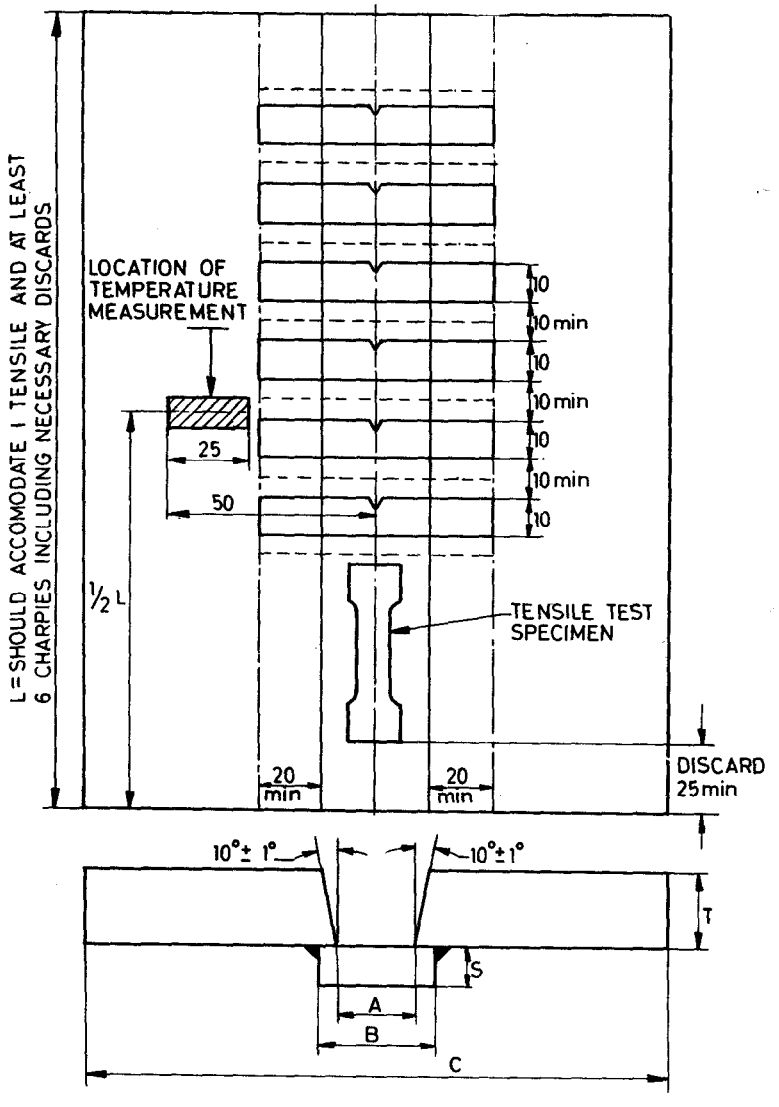
A-1.1 The parent metal for plates used in preparing test pieces shall be according to IS 2062 : 1992, IS 2002 : 1992 and IS 3039 : 1988. The test specimen shall not be subjected to any mechanical or thermal treatment other than that required under this Annex.

A-1.2 All weld metal test pieces shall be prepared as shown in Fig. 1 by depositing weld metal between the chamfered edges of the two plates placed on a backing strip. The backing strip shall be tack welded to the test assembly. The backing strip material shall also be made from a steel used for all weld assemblies described in **A-1.1**.

A-1.3 The dimensions of test assembly are shown in Fig. 1 and given in Table 8. The length of the plate shall be enough to accommodate a tensile test specimen and at least six charpy V-notch test specimen as shown in Fig. 1.

A-1.4 The plates edges shall be bevelled by machining or machine gas cutting. In the latter case, any remaining scale should be removed from bevelled edges. The surface of the backing strip should be free from rust or scale.

A-1.5 In order to counteract shrinkage deformation the test assembly should be present as shown in Fig. 2 in such a way that after completion of welding a level joint is obtained.



All dimensions in millimetres.

FIG. 1 DIMENSIONS OF TEST ASSEMBLY AND POSITION OF CUTTING OF TEST PIECES

Table 8 Dimensions of Test Assembly

(*Clause* **A-1.3**)

All dimensions in millimetres.

Plate Width, *C*	Plate Thickness, *T*	Width of Welding Gap, *A*	Backing Strip	
			Width, *B* *Min*	Thickness, *S* *Min*
120 ± 10	20 ± 1	20 ± 1	A + 10	10

A-2 TEST CONDITIONS

	For GMAW		*For GTAW*	
Standard Size, mm	1.2	1.6	2.4	3.2
Shielding gas	CO_2	CO_2	Argon	Argon
Electrode feed rate, mm/sec	190	102	–	–
Nominal arc voltage, V	27 to 31	26 to 30	13 to 60	16 to 19
Resulting current, A	260 to 290	330 to 360	220 to 250	250 to 280
Type of current	DCRP (DCRP = Electrode positive)		DCSP (DCSP = Electrode negative)	
* Tip to work distance, mm	19 ± 3	19 ± 3	–	–
Travel speed, mm/sec	5.5 ± 0.5	5.5 ± 0.5	0.17 to 0.25	0.17 to 0.25
Interpass Temp, °C	150 ± 15	150 ± 15	150 ± 15	150 ± 15

* Distance from the contact tip-to-work, not from the shielding gas cup to the work.

NOTE – The required combinations of electrode feed rate, arc voltage and tip-to-work distance should produce welding currents in the range shown. Currents substantially outside these ranges suggest errors in feed rate, tip-to-work distance, voltage settings, or in instrumentation.

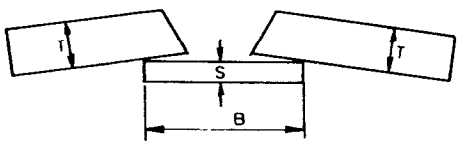


FIG. 2 PRESENTING OF TEST ASSEMBLY

A-3 When the assembly has been welded completely, it shall be allowed to cool in still air to room temperature. The portion including the weld shall then be removed by cutting away the excess plate at the places indicated in Fig. 1, cutting along the chain lines (shown by – – –) may be done mechanically or by machine gas cutting. Along the longitudinal boundaries (shown by broken lines as - - - - -) of the parts to be machined into impact test pieces cutting should be done by mechanical methods only.

A-4 HEAT TREATMENT TO ALL WELD TENSILE TEST PIECES

A-4.1 The all weld test pieces shall be heat treated in a furnace at a temperature of 250°C for a period of not less than 6 h and not more than 16 h. After the soaking period, the specimen shall be withdrawn from the furnace and allowed to cool slowly, protected from drought and chilling.

A-4.2 The purpose of heat treatment is to remove hydrogen from weld metal.

A-4.3 The impact test pieces shall not be heat treated.

A-5 ALL WELD TENSILE TEST

The tensile test specimen shall be machined from the weld metal test pieces in accordance with IS 1608 : 1995, care being taken that the longitudinal axis of the test specimen coincides with the central lines of the weld and the middle thickness of the plate (*see* Fig. 3) . The dimensions of the specimen shall be as shown in Fig. 4. The specimen shall be tested in accordance with IS 1608 : 1995.

A-6 ALL WELD IMPACT TEST

The impact test specimen shall be machined from the weld metal test pieces to the dimensions given in Table 9 in accordance with IS 1757 : 1979. Care being taken that the longitudinal axis of the specimen are perpendicular to the weld axis and upper surface of the plate. The notch shall be positioned in the centre of the weld and is to be cut on the face of the test piece perpendicular to the surface of the plate (*see* Fig.5). The tests are to be conducted at the test temperature on an approved impact machine.

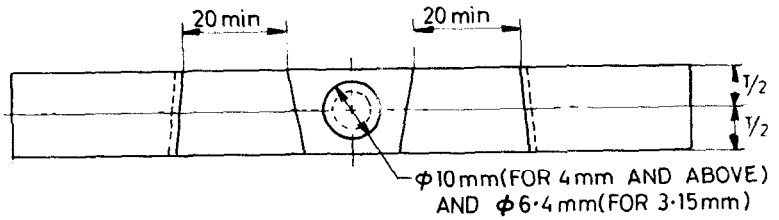


FIG. 3 CUTTING OF TENSILE TEST PIECE

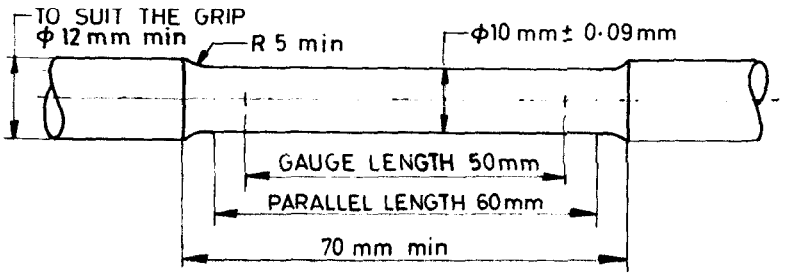


FIG. 4 TENSILE TEST PIECE

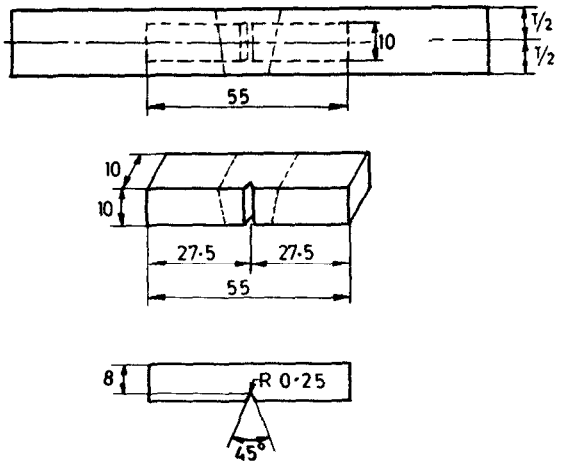


FIG. 5 IMPACT TEST PIECES/ASSEMBLY

Table 9 Dimensions of Impact Test Specimen

(*Clause* A-6)

All dimensions in millimetres.

Length	Width	Thickness	Angle of Notch	Root Radius of Notch	Depth Between Notch (Measured at the Both End)	Distance from Either End of test Piece
55 ± 0.6	10 ± 0.11	10 ± 0.11	45° ± 2°	0.25 ± 0.025	8 ± 0.11	27.5 ± 0.42

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 323 01 31, 323 94 02, 323 83 75

Telegrams: Manaksanstha
(Common to
all offices)

Regional Offices: Telephone

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002 — 323 76 17, 323 38 41

Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola
CALCUTTA 700054 — 337 84 99, 337 85 61, 337 86 26, 337 86 62

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022 — 60 38 43, 60 20 25

Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113 — 235 02 16, 235 04 42, 235 15 19, 235 23 15

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