IS 3613 (1974): Acceptance tests for wire flux combination for submerged arc welding [MTD 11: Welding General]

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IS : 3613 - 1974

Indian Standard

ACCEPTANCE TESTS FOR WIRE-FLUX COMBINATIONS FOR SUBMERGED-ARC WELDING OF STRUCTURAL STEELS

(First Revision)

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

Gr 7

May 1975

AMENDMENT NO. 1 AUGUST 1986

TO

IS:3613-1974 ACCEPTANCE TESTS FOR WIRE-FLUX COMBINATIONS FOR SUBMERGED-ARC WELDING OF STRUCTURAL STEELS

(First Revision)

(*Page 5, clause 1.1.1*) - Substitute the following for the existing clause:

'1.1.1 The standard covers acceptance tests for wire flux combinations for submerged arc welding of carbon steel and medium-tensile steel having a tensile strength of not more than 700N/mm^2 and a sulphur and phosphorous content of not greater than 0.06 percent each.'

(*Page 8, clause 1.6.2*) - Substitute the following for the existing clause:

'1.6.2 *X-Ray Examination* - It is recommended that the welded assembly be subjected to radiographic examination to ascertain any welding, defects in the weld prior to testing. The backing strip/plate shall be removed by machining before conducting radiographic examination.'

(*Page 10, clause 1.6.3.2, first sentence*) - Substitute the following for the existing sentence:

'The test pieces for the tensile test shall be heated between 200°C to 250°C for a period of 16 hours for hydrogen removal prior to testing.'

(*Page 14, clause 1.8.1.2, line 4*) - Substitute '1 mm' for '0.1 mm'

(*Page 16, Fig. 10, captions*) - Substitute '36 mm' *for* '30 mm'.

(*Page 16, clause 1.8.4, third sentence*) - Substitute the following for the existing sentence:

'The test specimen shall be heated between 200°C to 250°C for a period of 16 hours for hydrogen removal prior to testing.'

(*Page 26, Table 1, col 2, line 1*) - Substitute 'IS:226-1975' *for* 'IS:226-1969'.

(*Page 26, Table 1, col 2, line 5*) - Substitute 'IS:961-1975' *for* 'IS:961-1962'.

Reprography Unit, ISI, New Delhi, India

Indian Standard

ACCEPTANCE TESTS FOR WIRE-FLUX COMBINATIONS FOR SUBMERGED-ARC WELDING OF STRUCTURAL STEELS

(First Revision)

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(*Continued on page* 2)

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(*Continued on page* 27)

Indian Standard

ACCEPTANCE TESTS FOR WIRE-FLUX COMBINATIONS FOR SUBMERGED-ARC WELDING OF STRUCTURAL STEELS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 31 October 1974, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Since publication of this standard in 1966, the welding industry has gained experience in submerged-arc welding. A number of units has been set up to manufacture wires and fluxes and a separate Indian Standard specification (IS : 7280-1974*) is available covering wires; and a specification for fluxes† is under preparation. This standard is being revised introducing grades of the wire-flux combinations on the basis of charpy impact values at different specified temperatures indicating the technique of welding used, since it is desirable in submerged-arc welding to know whether impact values are obtained on weld deposit produced by using the multi-run technique or two-run technique. The impact values of submerged-arc welds in themselves do not necessarily indicate the suitability of weld metal for a given application and they should be regarded only as an index of the metallurgical quality of the weld metal. The grade numbers also indicate the minimum yield stress required from the all weld tests.

0.3 The wire-flux combinations are divided into two categories, namely:

a) for use with the multi-run technique; and

b) for use with the two-run technique, in this case a butt-weld is made with one run from each side.

Where a manufacturer states that a particular wire-flux combination is suitable for welding with both techniques, both series of tests are to be carried out.

*Specification for bare wire electrodes for submerged arc welding of structural steels.

†Classification and coding of fluxes for submerged arc welding of structural steel (*under preparation*).

As a rule, better mechanical properties are achieved by the multi-run technique than by the two-run technique. On the other hand, certain wire-flux combinations designed for two-run technique are known to give definitely better results with two-run technique than with the multi-run technique. For this reason, it is proposed that wire-flux combinations should be accepted separately for multi-run and for two-run welding. Multi-run welding will be indicated by 'M' and two-run welding by 'T' in the grade numbers immediately after the impact gradation. The yield stress (in N/mm^2) will form the last digits. This standard also introduces SI units to represent the test results.

0.4 The methods of testing and requirements laid down in this standard are intended primarily for acceptance of wire-flux combinations for automatic and semi-automatic single electrode submerged-arc welding, but they may also be used to a limited extent for acceptance of such combination of other types of submerged-arc welding such as multi-wire and multi-power source welding.

0.5 The test requirements laid down in this standard including radiographic quality, are for acceptance tests only and are not intended to be used for design purposes. For this reason the test specimens are not required to be heat-treated before testing (except for low temperature heat treatment to remove hydrogen where specified) regardless whether the welded constructions for which the wire-flux combinations are to be used, are heat-treated or not.

0.6 Bend test has been introduced in this standard as it may reveal inter-dendritic cracks that are not revealed by radiography.

0.7 This standard has been prepared in a manner that will not inhibit developments in wire-flux combinations. During recent years there has been a considerable improvement in the impact values that can be obtained using submerged-arc welding. In some cases higher values can now be obtained from welds made by manual metal-arc welding using hydrogen controlled electrodes. This is a developing situation and it is expected, for example, that wires and fluxes capable of giving better values than those stipulated for grades SA2T450 will become commercially available.

0.8 Manufacturers usually produce a range of fluxes based on various combinations of compounds. The ratio of basic to acid compounds in a flux is known as the basicity value and the recent work indicates that the higher the basicity value the higher will be the impact properties of the weld metal. This is a complex subject, and in case when weld metal ductility is important, the user is advised to consult the manufacturer of consumables, since the notch toughness of weld metal is a function not only of the flux chemistry but also of the weld metal chemistry and the weld micro-structure.

0.9 The suitability of a combination of wire and flux cannot be based solely on the numerical results obtained from the tests specified in this standard and other factors relative to the particular fabrication have to be taken into account. Amongst these are the minimum temperature that the fabrication will experience in service and the maximum stress to which the weld metal will be subjected. Also, the weld contour appearance and penetration may be important considerations. The user is, therefore, advised to carry out procedure tests to simulate his production application.

0.10 Although combinations of wires and fluxes supplied by different companies may be approved for the same grade, individual wires and fluxes are not necessarily interchangeable.

0.11 This standard keeps in view the manufacturing and trade practices being followed in the field in this country. Assistance has also been derived from the following publications:

BS 4165 : 1971 Specification for electrode wires and fluxes for the submerged-arc welding of carbon steel and medium tensile steel. British Standards Institution.

Doc : IIS/IIW-385-72 Classification and symbolization of bare steel wire electrodes and fluxes for submerged-arc welding of structural steel. International Institute of Welding.

0.12 The colour for radiographic quality corresponds to that of one group of radiographs from the International Institute of Weldings ' Collection of reference radiographs of welds ' published by Tekniska Rontgen-centralen, Stockholm.

0.13 In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

SECTION 1 GENERAL

1.1 Scope

1.1.1 This standard covers acceptance tests for wire-flux combinations for submerged-arc welding of mild and low alloy high tensile steels for thickness up to and including 35 mm by the two-run or multi-run techniques for use in structural work, general engineering work, pressure vessels and for hull construction. Approval obtained on the 20 mm thickness with the multi-run technique shall be deemed valid up to 35 mm thickness. Where the thickness exceeds 35 mm, additional tests are necessary and are to be mutually agreed upon.

*Rules for rounding off numerical values (*revised*).

1.1.2 Section 2 specifies requirements for acceptance tests for wire-flux combinations for use with the multi-run technique which give on all-weld metal tests, a tensile strength within the range 400-600 N/mm² (41-61 kgf/mm²) and the yield stress not less than 300 N/mm² (31 kgf/mm²). The elongation shall not be less than 22 percent.

1.1.3 Section 3 specifies requirements for acceptance tests for wire-flux combinations for use with multi-run technique which give on all-weld metal tests, a tensile strength within the range 460-650 N/mm² (47-66 kgf/mm²) and the yield stress not less than 350 N/mm² (36 kgf/mm²). The elongation shall not be less than 22 percent.

1.1.4 Section 4 specifies requirements for acceptance tests for wire-flux combinations for use with the multi-run technique which give on all-weld metal tests, a tensile strength within the range 520-700 N/mm² (53-71 kgf/mm²) and the yield stress not less than 450 N/mm² (46 kgf/mm²). The elongation shall not be less than 22 percent.

1.1.5 Section 5 specifies requirements for acceptance tests for wire-flux combinations for use with the two-run technique which give on longitudinal weld tests, a tensile strength within the range 400-600 N/mm² (41-61 kgf/mm²) and the yield stress shall not be less than 300 N/mm² (31 kgf/mm²). The elongation shall not be less than 22 percent.

1.1.6 Section 6 specifies requirements for acceptance tests for wire-flux combinations for use with the two-run technique which give on longitudinal weld tests, a tensile strength within the range 500-650 N/mm² (51-66 kgf/mm²) and the yield stress shall not be less than 350 N/mm² (36 kgf/mm²). The elongation shall not be less than 22 percent.

1.1.7 Section 7 specifies requirements for acceptance tests for wire-flux combinations for use with the two-run technique which give on longitudinal weld tests, a tensile strength within the range 550-700 N/mm² (56-71 kgf/mm²) and the yield stress shall not be less than 450 N/mm² (46 kgf/mm²). The elongation shall not be less than 22 percent.

1.2 Terminology

1.2.1 For the purpose of this standard the terms given in IS : 812-1957* in addition to the following shall apply.

1.2.1.1 *Multi-run technique* — A technique in which a complete weld is deposited in two or more runs from one or each side of a joint. The consecutive runs on each side of a joint may be deposited from separate wires fed concurrently.

1.2.1.2 *Two-run technique* — A technique in which a complete weld is deposited in a single run from each side of a joint, using one or more wires feeding one molten pool.

*Glossary of terms relating to welding and cutting of metals.

1.3 Material

1.3.1 *Parent Metal* — The parent metal used for test plates shall conform to the requirements specified in Appendix A.

1.3.2 *Bare Wire Electrode* — Bare wire for submerged-arc welding shall conform to IS : 7280-1974*.

1.3.3 *Fluxes* — Fluxes shall be classified and coded in accordance with the ' Indian Standard classification and coding of fluxes for submerged arc welding of structural steel ' (*under preparation*).

1.3.3.1 Fluxes shall be granular in nature and capable of free flow through the flux feeding tubes, valves and nozzles of standard welding equipment.

1.3.3.2 Sizing shall be uniform to the extent that flux of one container taken at random will be similar for each grade of flux.

1.3.3.3 *Packing and storage* — Flux shall be packed in moisture proof container and shall be protected from damage during transportation and storage. When stored the flux should be kept in its original container in a dry store-room and under such condition the flux shall, for a period of at least six months, be capable of giving results similar to those it would have given on the date of its despatch from the manufacturer.

1.4 Test Requirements — The wire and flux combinations shall be capable of complying in all respects with the test requirements of this standard. Wire-flux combinations suitable for use on both ac and dc (electrode positive or negative) should preferably be tested on ac but in all cases the current used in the tests shall be reported.

1.5 Initial Tests — These comprise the initial tests to which each type or modified type of wire and flux shall be subjected and it is implicit in the manufacturer's certificate that the wires and fluxes in current production are capable of satisfying the whole of test requirements.

1.5.1 *Initial Tests for Multi-run Technique* — When approval for use with multi-run technique is required, all-weld metal and butt-weld tests are required to be carried out in accordance with **1.6** and **1.7**.

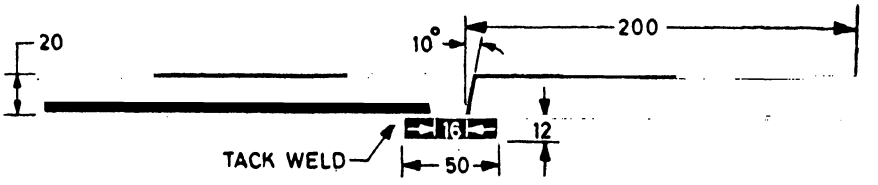
1.6 All-Weld Metal Tests

1.6.1 *Preparation of Weld Assembly*

1.6.1.1 Tensile and impact tests are to be made under controlled conditions from the metal deposited from the wire-flux combinations.

*Specification for bare wire electrodes for submerged arc welding of structural steels.

1.6.1.2 An all-weld metal test assembly is to be prepared in the down hand position as shown in Fig. 1 and 2.



All dimensions in millimetres.

FIG. 1 DIMENSIONS OF ALL-WELD METAL TEST ASSEMBLY

1.6.1.3 The bevelling of the plate edges shall be carried out by machining or mechanized gas cutting. Oil, dirt, rust and scale shall be removed from the fusion faces before welding. The surface of the backing strip shall be free from rust and scale. The backing strip shall be tack welded to the 20 mm plates.

1.6.1.4 The plates shall be preset so that they are approximately flat after the welding operation has been completed.

1.6.1.5 The welding shall be carried out with that combination of wire and flux which is to be approved. It should be ensured that the wire is clean and free from oil, grease, paint and rust and that the flux is dried according to manufacturer's recommendation before use.

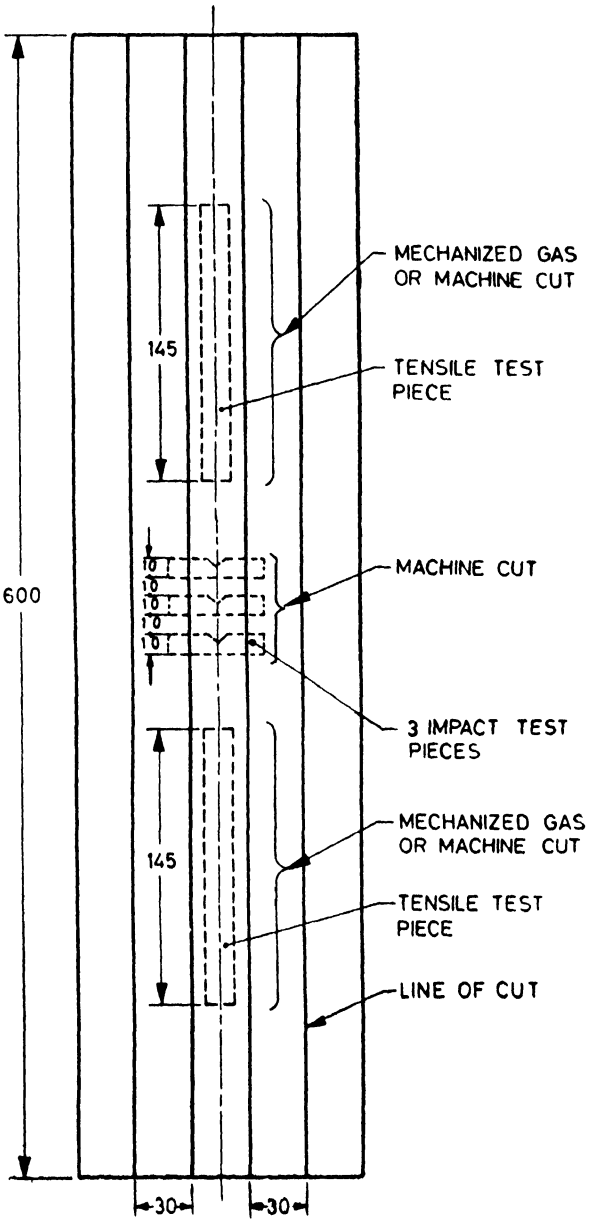
1.6.1.6 The welding conditions (current, voltage and rate of travel) shall be in accordance with the recommendations of the manufacturer and conform to normal good welding practice for multi-run technique.

1.6.1.7 The welding current may be either ac or dc (electrode positive or negative) according to the recommendations of the manufacturer. If both are permitted ac shall be used for the tests.

1.6.1.8 It is advisable to start and end welding on run-on and run-off plates tack welded to the test plates. The direction of deposition of each run is to alternate from each end of the plate, and after completion of each run the flux and welding slag is to be removed. Between each run the test piece is to be left in still air until it has cooled to 250°C (controlled by test colour or other adequate methods) the temperature being taken in the centre of the weld, on the surface of the seam. The thickness of the layer is not to be less than the diameter of the wire but not less than 4 mm.

1.6.1.9 The welded test piece shall be cut as shown in Fig. 2.

1.6.2 *X-Ray Examination* — It is recommended that the test piece be subjected to radiographic examination after machining off the specimen plate to ascertain any defect in the weld prior to testing. Alternatively all the cut edges of the weld shall be etched to check the presence of the weld defects.

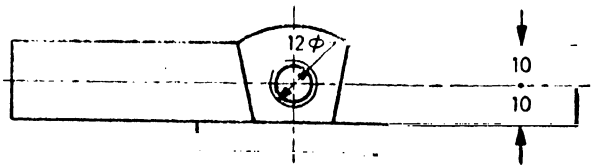


All dimensions in millimetres.

FIG. 2 DIMENSIONS OF ALL WELD METAL TEST PIECES

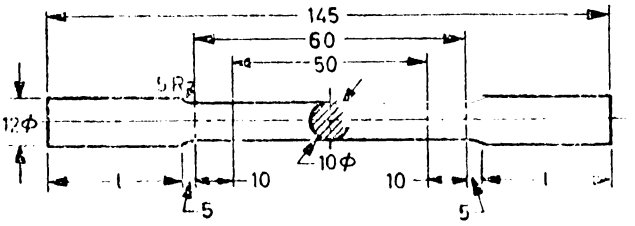
1.6.3 *Tensile Test*

1.6.3.1 Two tensile test pieces shall be cut from the test pieces according to the indications given in Fig. 2 and 3 and machined to the dimensions given in Fig. 4, care being taken that the longitudinal axis coincides with the centre of the weld and the mid-thickness of the plates.



All dimensions in millimetres.

FIG. 3 LOCATION OF THE ALL-WELD METAL TENSILE TEST SPECIMEN



All dimensions in millimetres.

FIG. 4 DIMENSIONS OF THE TENSILE TEST SPECIMEN TO BE MACHINED

1.6.3.2 The test pieces for the tensile test specimens shall be subjected to a temperature not exceeding 250°C for a period not exceeding 16 hours for hydrogen removal prior to testing. The tensile test shall be carried out at the ambient temperature according to IS : 1608-1972*.

1.6.3.3 Each test specimen shall fulfil the requirements of deposited metal tensile test.

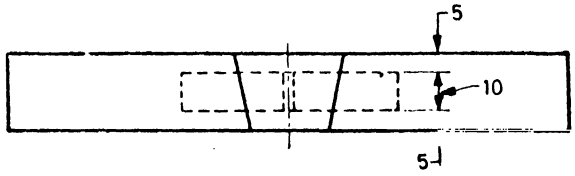
1.6.4 *All-Weld Metal Impact Test*

1.6.4.1 The impact test specimens are to be of the Charpy V-notch type.

1.6.4.2 Three impact test specimens shall be cut from the test piece as shown in Fig. 2 and 5, care being taken that their longitudinal axis is perpendicular to the weld and taken from mid-thickness of the plates. The dimensions of the test specimens are given as in Fig. 6.

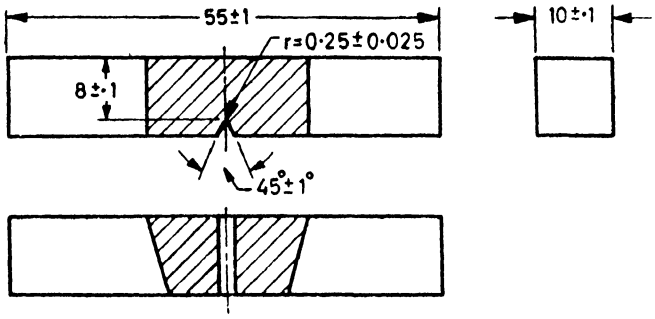
1.6.4.3 The notch shall be positioned in the centre of the weld and shall be cut in the face of test specimens perpendicular to the surface of the plates as shown in Fig. 5. The test shall be carried out in accordance with IS : 1757-1961†.

*Method for tensile testing of steel products (*first revision*).
†Method for beam impact test (V-notch) on steel.



All dimensions in millimetres.

FIG. 5 LOCATION OF THE ALL-WELD METAL IMPACT TEST SPECIMEN



All dimensions in millimetres.

FIG. 6 DIMENSIONS OF THE IMPACT TEST SPECIMEN TO BE MACHINED

1.7 Multi-run Butt-Weld Tests

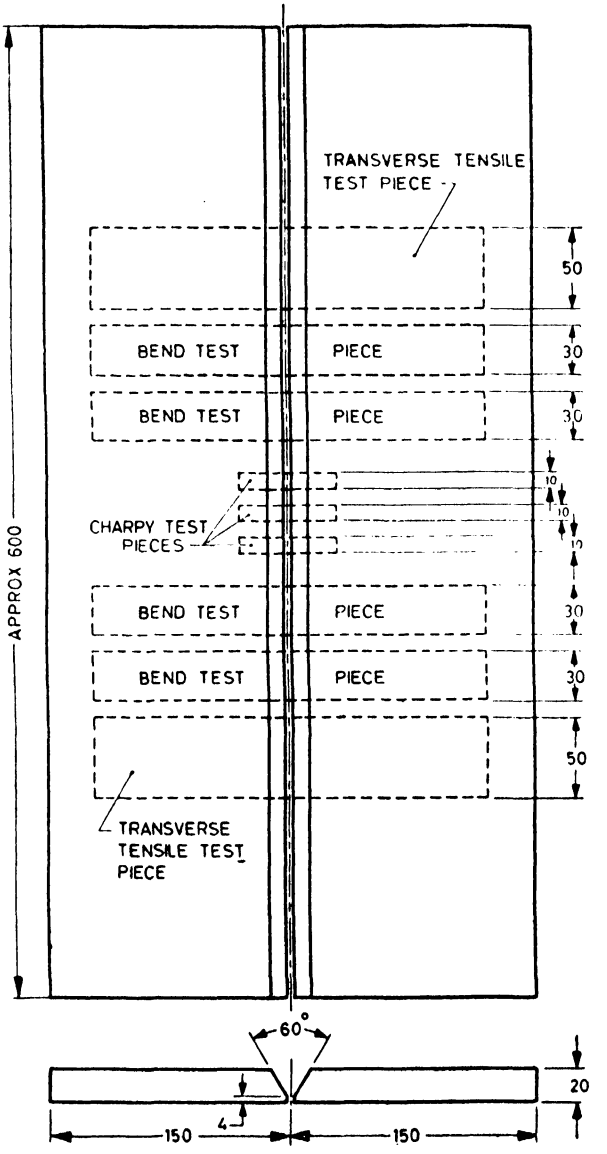
1.7.1 *Preparation of Weld Assembly*

1.7.1.1 A butt-weld assembly as shown in Fig. 7 shall be prepared in the downhand position by welding together two 20-mm plates not less than 150 mm in width and of sufficient length (approximately 600 mm) to allow the cutting out of test specimens of the prescribed number and size.

1.7.1.2 The plate edges shall be prepared to form a single V-joint, the included angle between the fusion faces being 60° and the root face being 4 mm. The bevelling of the plate edges shall be carried out by machining or mechanized gas cutting. In the latter case, any remaining scale shall be removed from the bevelled edges.

1.7.1.3 The plates shall be so preset that they are approximately flat after the welding operation has been completed. The welding shall be carried out by the multi-run technique and the welding conditions (current, voltage and speed) shall be in accordance with the recommendations of the manufacturer and shall conform to normal good welding practice for multi-run technique.

1.7.1.4 Wire-flux combinations suitable for use on both ac and dc (electrode positive or negative) should preferably be tested on ac.



All dimensions in millimetres.

FIG. 7 METHOD OF CUTTING TEST SPECIMENS FROM A BUTT-WELD ASSEMBLY

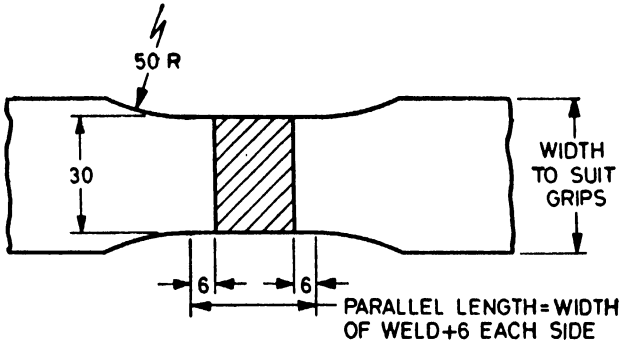
1.7.1.5 The back sealing run shall be applied in the downhead position after removing the root run to clean metal.

1.7.1.6 After being welded, the test piece shall not be subjected to any heat treatment.

1.7.1.7 It is recommended that the test piece be subjected to a radiographic examination to ascertain any defects in the weld prior to testing.

1.7.1.8 The test piece shall then be cut to form two transverse tensile, two face bend, two root bend and three Charpy V-notch impact specimens as shown in Fig. 7.

1.7.2 *Butt-Weld Tensile Tests* — Two transverse tensile specimens shall be machined to the dimensions as given in Fig. 8. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate. Where the surfaces of the plate are not level with each other, the metal may be cut away to bring them approximately level, provided that the thickness of the plate is not reduced by more than a total of 1 mm. The tensile strength of each specimen shall not be less than the specified values prescribed in Sections 2 to 7.



All dimensions in millimetres.

FIG. 8 BUTT-WELD TENSILE TEST SPECIMEN

1.7.3 *Butt-Weld Bend Tests*

1.7.3.1 Four transverse bend test specimens, 30 mm in width, shall be taken from the welded assembly. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate and the sharp corners of the specimens rounded to a radius not exceeding 2 mm. The test specimens shall be capable of being bent through an angle of 120° without fracture over a former having a diameter three times the thickness of the specimen. Two specimens shall be tested with the face of the weld in tension and two specimens with the root of the weld in tension. Where the surfaces of the plates are not level with each other, the metal may be cut away to bring them approximately level, provided that the thickness of the plate is not reduced by more than a total of 1 mm.

1.7.3.2 The test specimens shall be considered as complying with the test if, on completion of the test, no crack or defect at the outer surface of the test specimen is greater than 3 mm when measured across the specimen or 1·5 mm when measured along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

1.7.4 *Butt-Weld Impact Test* — Three Charpy V-notch impact test pieces shall be machined from the test assembly. The test specimens shall be prepared as shown in Fig. 5 and 6. The test pieces shall be cut with their longitudinal axes perpendicular to the weld. The test specimens shall be taken from the middle of the plate thickness with the notch perpendicular to the surface of the plate. The average value of the Charpy impact tests shall be as given in Sections 2 to 7.

1.8 Initial Tests for Two-Run Technique

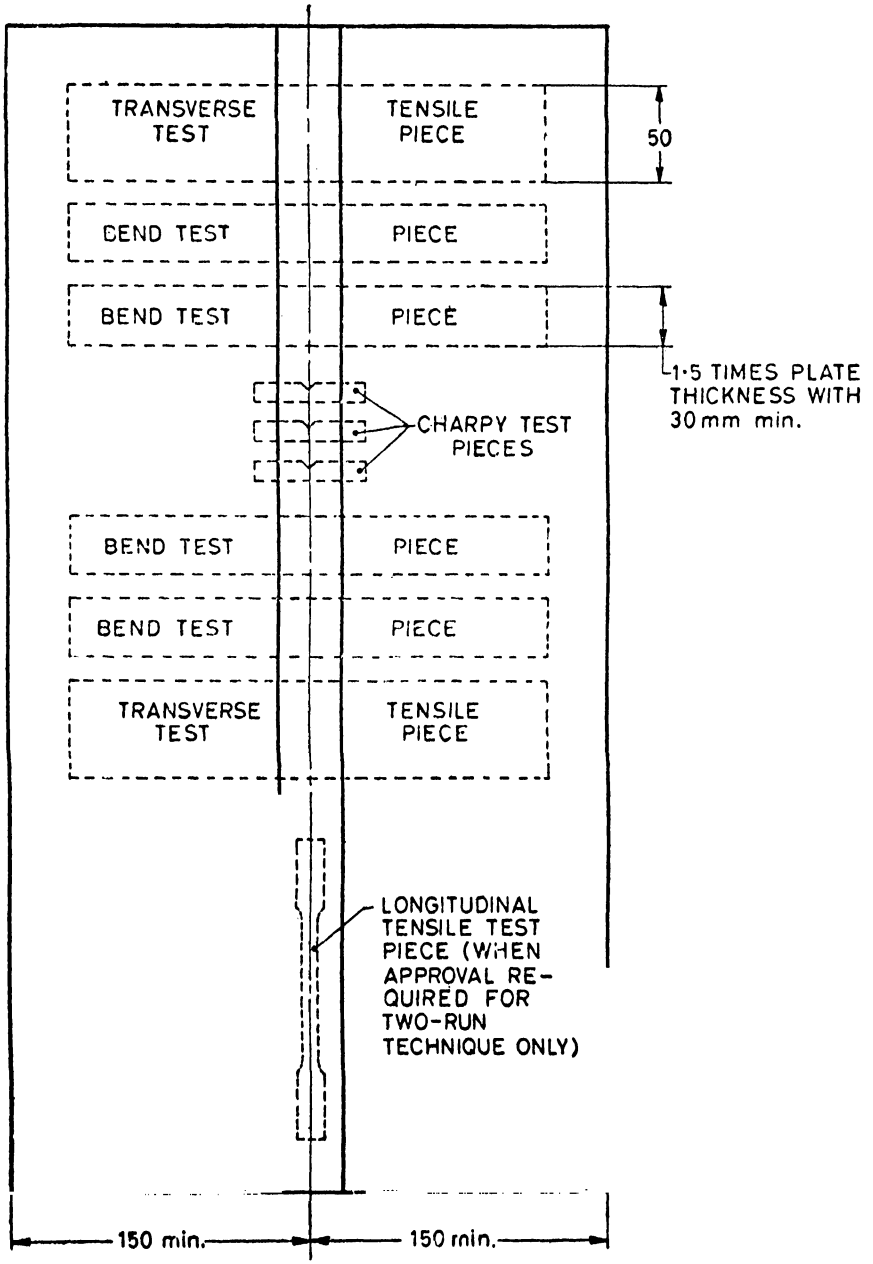
1.8.1 *Preparation of Weld Assembly*

1.8.1.1 Two welded test pieces shall be prepared — one each with 12 to 15 mm and 20 mm plate thickness as shown in Fig. 9 using the plate material as specified in Appendix A. The maximum diameter of the wire and edge preparation to be used shall be in accordance with Fig. 10. Small deviation in the edge preparation may be allowed if recommended by the manufacturer.

1.8.1.2 The bevelling of the plate edges shall be performed by machining or mechanized gas cutting. In the latter case, any remaining scale shall be removed from the bevelled edges. The root gap should not exceed 0·1 mm. Each butt-weld shall be welded in two run, one from each side, using current voltages and travel speeds in accordance with the recommendations of the manufacturer and normal good welding practice. After completion of the first run, the flux and welding slag shall be removed and the assembly shall be left in still air until it has cooled to 100°C, the temperature being taken in the centre of the weld, on the surface of the seam. After being welded, the test pieces shall not be subjected to any heat treatment. The two discard ends (40 mm, *Min*) shall be prepared and etched to check for interlocking of welds.

1.8.2 *X-Ray Examination* — It is recommended that the welded test piece be subjected to radiographic examination to ascertain any defects in the weld prior to testing.

1.8.3 *Butt-Weld Tensile Tests* — Two transverse tensile specimens shall be machined to the dimensions as given in Fig. 8. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surfaces of the plates. Where the surfaces of the plates are not level with each



All dimensions in millimetres.

FIG. 9 METHOD OF CUTTING TEST PIECE FROM ASSEMBLY FOR TWO-RUN TECHNIQUE

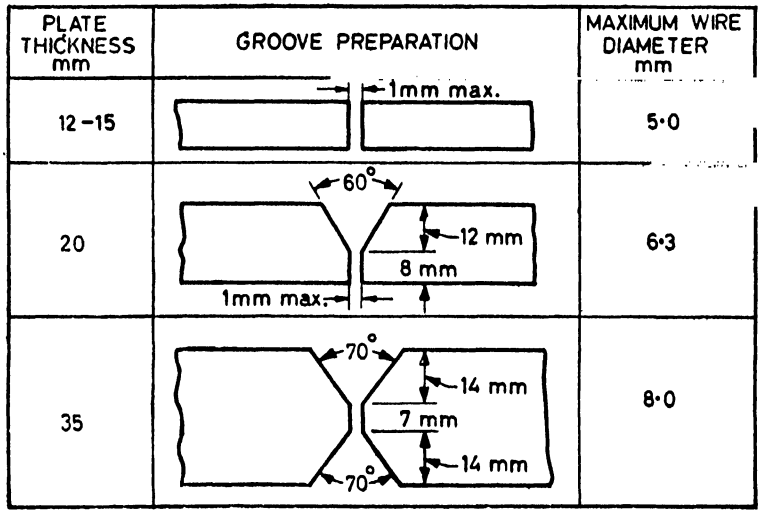


FIG. 10 WIRE DIAMETER FOR EDGE PREPARATION OF PLATES 12, 20 AND 30 mm THICK

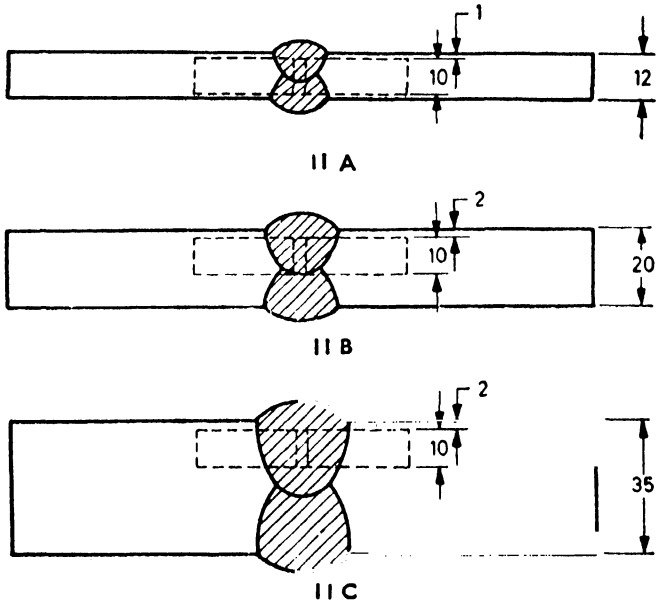
other, the metal may be cut away to bring them approximately level, provided that the thickness of the plate is not reduced by more than a total of 1 mm. The tensile strength of each specimen shall not be less than the specified values in the respective sections.

1.8.4 *Longitudinal Weld Tensile Test* — When a wire-flux combination has to be approved for two-run welding only, one additional longitudinal tensile test specimen shall be taken out from the positions as shown in Fig. 9 from each test piece and machined according to Fig. 4. The longitudinal axis shall coincide with the centre of the weld about 7 mm below the plate surface on the side from which the second run is made. The test specimen shall be subjected to a temperature not exceeding 250°C for a period not exceeding 16 hours for hydrogen removal, prior to testing. The tensile strength of each test specimen shall not be less than the specified values in the respective sections.

1.8.5 *Butt-Weld Bend Tests* — Four transverse bend test specimens, 30 mm in width, shall be taken from the test piece. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate and the sharp corners of the specimens rounded to a radius not exceeding 2 mm. The test specimens shall be capable of being bent through an angle of 120° without fracture over a former having a diameter three times the thickness of the specimen. Two specimens shall

be tested with the face of the weld in tension and two specimens with the root of the weld in tension. Where the surfaces of the plates are not level with each other, the metal may be cut away to bring them approximately level, provided that the thickness of the plate is not reduced by more than a total of 1 mm.

1.8.6 *Butt-Weld Impact Tests* — Charpy V-notch impact tests shall be carried out on three test specimens from each welded test piece. The position of the test specimen and of the notch in relation to the welded seam is shown in Fig. 11. The average of the three impact values shall not be less than that specified in the respective section.



All dimensions in millimetres.

FIG. 11 LOCATION OF BUTT-WELD IMPACT TEST SPECIMENS

1.9 Periodic Check Tests — Periodic check tests consist of a selection of specified tests and they shall be repeated at intervals not exceeding 12 months to provide evidence that the wire and flux combinations continue to possess the properties recorded in the initial tests. Samples of approved wire-flux combinations shall be subjected to at least the following tests annually.

1.9.1 *Periodic Check Tests for Multi-run Welding*

1.9.1.1 *All-weld metal test* — Two tensile and three impact tests shall be carried out on specimens taken from the all-weld metal test piece.

1.9.2 *Periodic Check Test for Two-Run Welding*

1.9.2.1 Two transverse tensile, four bend and three impact tests shall be carried out on transverse specimens taken from a 20 mm V-butt weld test piece.

1.10 X-Ray Examination

1.10.1 Only when a wire-flux combination is approved for application of pressure vessels, in addition to the prescribed tests, the test pieces shall be subjected to a radiographic examination to ascertain any defect in weld.

1.11 Production Control Tests — By means of suitable system of control and testing, the manufacturer shall ensure that the wires and fluxes currently provided would meet the same requirements as those approved in the initial tests.

The results of the production control tests and the dates of manufacture shall be capable of being traced from the batch number.

1.12 Additional Tests — Subject to agreement with the manufacturer, the purchaser may request for additional tests to be made or certificates to be provided for each batch of wire-flux combination supplied. If so, the tests and batch definition shall be agreed to between the purchaser and the supplier.

1.13 Re-tests — When any test specimen fails to satisfy the test requirement, twice the number of specimens specified for initial or periodic check tests shall be prepared using wire and fluxes preferably from the same batches and submitted to the tests in which failure occurred. Provided that the tests are satisfactory, the wire and the flux may be accepted as having passed the test.

SECTION 2 MULTI-RUN TECHNIQUE: ALL-WELD METAL TENSILE STRENGTH 400-600 N/mm² (41-61 kgf/mm²), MINIMUM YIELD STRESS 300 N/mm² (31 kgf/mm²), NOT COVERED BY SECTION 3 OR 4

2.1 All-Weld Tensile Test — The strength of each test specimen shall be within the range 400 to 600 N/mm² (41 to 61 kgf/mm²) and the yield stress not less than 300 N/mm² (31 kgf/mm²). The elongation shall be not less than 22 percent.

2.2 All-Weld Metal Impact Tests — The average of the three impact values shall not be less than the following:

Grade	*Average Impact Values (Min)*		*Testing Temperature* °C
	J	kgf.m	
SA 1 M 300	35	3·5	(Room Temp) 20 Approx
SA 2 M 300	35	3·5	0 ± 1
SA 3 M 300	35	3·5	−20 ± 1
SA 4 M 300	35	3·5	−40 ± 1

The results of the impact tests shall be assessed as specified in **2.2.1.**

2.2.1 The average $\bar{x}_3$ of the results of the three tests shall be assessed as follows:

$\bar{x}_3$ J	*Assessment*
Up to and including 30	Requirement *not* fulfilled
Including and over 35	Requirement *fulfilled*

If the value of $\bar{x}_3$ lies between 30 and 35 J, three additional specimens shall be prepared and tested, and the results added to those previously obtained to form a new average $\bar{x}_6$. If the value of $\bar{x}_6$ is 35 J or above, the wire-flux combination shall be deemed to have fulfilled the requirements.

If the value of $\bar{x}_6$ is less than 35 J, further six specimens shall be prepared using the same batch of wire and fluxes if possible and tested, and the results added to the previous value of $\bar{x}_6$ to form a new average $\bar{x}_{12}$ the value of which shall be not less than 35 J.

2.3 Chemical Composition — The percentage contents of carbon, manganese, silicon, sulphur and phosphorus in the deposited weld metal from the all-weld test piece may be reported. The sulphur and phosphorus content shall not exceed 0·05 percent each.

2.4 Transverse Tensile Tests — Two transverse tensile specimens shall be prepared in accordance with the method specified in **1.7.2**.

The tensile strength of each specimen shall not be less than 400 N/mm² (41 kgf/mm²).

2.5 Transverse Bend Test — Four transverse bend specimens shall be prepared and tested in accordance with the method specified in **1.7.3**.

2.5.1 Each test specimen satisfies if bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimens, no crack or defect at the outer surface of the specimen is greater than 3 mm measured across the specimen or 1·5 mm along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

SECTION 3 MULTI-RUN WELDING : ALL-WELD METAL TENSILE STRENGTH 460-650 N/mm² (47-66 kgf/mm²), MINIMUM YIELD STRESS 350 N/mm² (36 kgf/mm²), NOT COVERED BY SECTION 2 OR 4

3.1 All-Weld Tensile Tests — The tensile strength of each specimen shall be within the range 460*-650 N/mm² (47-66 kgf/mm²) and the yield stress not less than 350 N/mm² (36 kgf/mm²). The elongation shall be not less than 22 percent.

*The lower limit of the range of tensile strength has been reduced from the minimum value specified for the transverse tensile test since with the type of weld preparation used for the all-weld test pieces, dilution from the parent metal is less.

3.2 All-Weld Impact Tests — The average of the three impact values shall not be less than the following:

Grade	*Average Impact Values (Min)*		*Testing Temperature* °C
	J	kgf.m	
SA 1 M 350	40	4·0	(Room Temp) 20 Approx
SA 2 M 350	40	4·0	0 ± 1
SA 3 M 350	40	4·0	−20 ± 1
SA 4 M 350	40	4·0	−40 ± 1

3.2.1 The average $\bar{x}_3$ of the results of the three tests shall be assessed as follows:

$\bar{x}_3$ J	*Assessment*
Up to and including 34	Requirement *not* fulfilled
Including and over 40	Requirement *fulfilled*

If the value of $\bar{x}_3$ lies between 34 and 40 J, three additional specimens shall be prepared and tested, and the results added to those previously obtained to form a new average $\bar{x}_6$. If the value of $\bar{x}_6$ is 40 J or above, the wire-flux combination shall be deemed to have fulfilled the requirements.

If the value of $\bar{x}_6$ is less than 40 J, further six specimens shall be prepared using the same batch of wire and fluxes if possible and tested, and the results added to the previous value of $\bar{x}_6$ to form a new average $\bar{x}_{12}$ the value of which shall be not less than 40 J.

3.3 Chemical Composition — The percentage contents of carbon, manganese, silicon, sulphur and phosphorus in the deposited weld metal from the all-weld test piece may be reported. The sulphur and phosphorus content shall not exceed 0·05 percent each.

3.4 Transverse Tensile Tests — Two transverse tensile specimens shall be prepared in accordance with the method specified in **1.7.2**.

The tensile strength of each specimen shall be not less than 500 N/mm² (51 kgf/mm²).

3.5 Transverse Bend Test — Four transverse bend specimens shall be prepared and tested in accordance with the method specified in **1.7.3**.

Each test specimen satisfies if bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimen, no crack or defect at the outer surface of the specimen is greater than 3 mm measured across the specimen or 1·5 mm along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

SECTION 4 MULTI-RUN WELDING : ALL-WELD METAL TENSILE STRENGTH 520-700 N/mm² (53-71 kgf/mm²), MINIMUM YIELD STRESS 450 N/mm² (46 kgf/mm²), NOT COVERED BY SECTIONS 2 AND 3

4.1 All-Weld Tensile Test — The tensile strength of each specimen shall be within the range 520*-700 N/mm² (53-71 kgf/mm²) and the yield stress not less than 450 N/mm² (46 kgf/mm²). The elongation shall be not less than 22 percent.

4.2 All-Weld Impact Test — The average of the three impact values shall not be less than the following:

Grade	*Average Impact Values (Min)*		*Testing Temperature* °C
	J	kgf.m	
SA 1 M 450	47	4·7	(Room Temp) 20 Approx
SA 2 M 450	47	4·7	0 ± 1
SA 3 M 450	47	4·7	−20 ± 1
SA 4 M 450	47	4·7	−40 ± 1

4.2.1 The average $\bar{x}_3$ of the results of the three tests shall be assessed as follows:

$\bar{x}_3$ J	*Assessment*
Up to and including 40	Requirement *not* fulfilled
Including and over 47	Requirement *fulfilled*

If the value of $\bar{x}_3$ lies between 40 and 47 J, three additional specimens shall be prepared and tested, and the results added to those previously obtained to form a new average $\bar{x}_6$. If the value of $\bar{x}_6$ is 47 J or above, the wire-flux combination shall be deemed to have fulfilled the requirements.

If the value of $\bar{x}_6$ is less than 47 J, further six specimens shall be prepared using the same batch of wire and fluxes if possible and tested, and the results added to the previous value of $\bar{x}_6$ to form a new average $\bar{x}_{12}$ the value of which shall be not less than 47 J.

4.3 Chemical Composition — The percentage contents of carbon, manganese, silicon, sulphur and phosphorus in the deposited weld metal from the all-weld test piece may be reported. The sulphur and phosphorus content shall not exceed 0·05 percent each.

*The lower limit of the range of tensile strength has been reduced from the minimum value specified for the transverse tensile test since with the type of weld preparation used for the all-weld test pieces, dilution from the parent metal is less.

4.4 Transverse Tensile Tests — Two transverse tensile specimens shall be prepared in accordance with the method specified in **1.7.2.**

The tensile strength of each specimen shall be not less than 550 N/mm² (56 kgf/mm²).

4.5 Transverse Bend Test — Four transverse bend specimens shall be prepared and tested in accordance with the method specified in **1.7.3.**

Each test specimen satisfies if bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimens, no crack or defect at the outer surface of the specimen is greater than 3 mm measured across the specimen or 1·5 mm along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

SECTION 5 TWO-RUN WELDING : LONGITUDINAL WELD TENSILE STRENGTH 400-600 N/mm² (41-61 kgf/mm²), YIELD STRESS NOT LESS THAN 300 N/mm² (31 kgf/mm²), NOT COVERED BY SECTION 6 OR 7

5.1 Longitudinal Weld Tensile Test — One longitudinal weld tensile test specimen shall be prepared and tested in accordance with the method specified in **1.8.4.**

The tensile strength of the specimen shall be within the range 400-600 N/mm² (41-61 kgf/mm²) and the yield stress not less than 300 N/mm² (31 kgf/mm²). The elongation shall be not less than 22 percent.

5.2 Butt-Weld Impact Tests — Three impact test specimens shall be prepared in accordance with **1.8.6.** The average of the three impact values shall not be less than the following:

Grade	*Average Impact Values (Min)*		*Testing Temperature* °C
	J	kgf.m	
SA 1 T 300	35	3·5	(Room Temp) 20 Approx
SA 2 T 300	35	3·5	0 ± 1
SA 3 T 300	35	3·5	−20 ± 1
SA 4 T 300	35	3·5	−40 ± 1

The results of the impact tests shall be assessed as specified in **5.2.1.**

5.2.1 The average $\bar{x}_3$ of the results of the three tests shall be assessed as follows:

$\bar{x}_3$ J	*Assessment*
Up to and including 30	Requirement *not* fulfilled
Including and over 35	Requirement *fulfilled*

If the value of $\bar{x}_3$ lies between 30 and 35 J, three additional specimens shall be prepared and tested, and the results added to those previously obtained to form a new average $\bar{x}_6$. If the value of $\bar{x}_6$ is 35 J or above, the wire-flux combination shall be deemed to have fulfilled the requirements.

If the value of $\bar{x}_6$ is less than 35 J, further six specimens shall be prepared using the same batch of wire and fluxes if possible and tested, and the results added to the previous value of $\bar{x}_6$ to form a new average $\bar{x}_{12}$ the value of which shall be not less than 35 J.

5.3 Chemical Composition — The percentage contents of carbon, manganese, silicon, sulphur and phosphorus in the deposited weld metal from the all-weld test piece may be reported. The sulphur and phosphorus content shall not exceed 0·05 percent each.

5.4 Transverse Tensile Tests — Two transverse tensile specimens shall be prepared in accordance with the method specified in **1.8.3**.

The tensile strength of each specimen shall not be less than 400 N/mm^2.

5.5 Transverse Bend Test — Four transverse bend specimens shall be prepared and tested in accordance with the method specified in **1.8.5**.

Each test specimen satisfies if bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimens no crack or defect at the outer surface of the specimen is greater than 3 mm measured across the specimen or 1·5 mm along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

SECTION 6 TWO-RUN WELDING : LONGITUDINAL WELD TENSILE STRENGTH 500-650 N/mm^2 (51-66 kgf/mm^2), YIELD STRESS NOT LESS THAN 350 N/mm^2 (36 kgf/mm^2), NOT COVERED BY SECTION 5 OR 7

6.1 Longitudinal Weld Tensile Test — One longitudinal weld tensile test specimen shall be prepared and tested in accordance with the method specified in **1.8.4**.

The tensile strength of the specimen shall be within the range 500-650 N/mm^2 (51-66 kgf/mm^2) and the yield stress not less than 350 N/mm^2 (36 kgf/mm^2). The elongation shall be not less than 22 percent.

6.2 Butt-Weld Impact Tests — Three impact test pieces shall be prepared in accordance with **1.8.6**. The average of the three impact values shall

not be less than the following:

Grade	*Average Impact Values (Min)*		*Testing Temperature* °C
	J	kgf.m	
SA 1 T 350	40	4·0	(Room Temp) 20 Approx
SA 2 T 350	40	4·0	0 ± 1
SA 3 T 350	40	4·0	−20 ± 1
SA 4 T 350	40	4·0	−40 ± 1

The results of the impact tests shall be assessed as specified in **6.2.1**.

6.2.1 The average $\bar{x}_3$ of the results of the three tests shall be assessed as follows:

$\bar{x}_3$ J	*Assessment*
Up to and including 34	Requirement *not* fulfilled
Including and over 40	Requirement *fulfilled*

If the value of $\bar{x}_3$ lies between 34 and 40 J, three additional specimens shall be prepared and tested, and the results added to those previously obtained to form a new average $\bar{x}_6$. If the value of $\bar{x}_6$ is 34 J or above, the wire-flux combination shall be deemed to have fulfilled the requirements.

If the value of $\bar{x}_6$ is less than 34 J, further six specimens shall be prepared using the same batch of wire and fluxes if possible and tested, and the results added to the previous value of $\bar{x}_6$ to form a new average $\bar{x}_{12}$ the value of which shall be not less than 34 J.

6.3 Chemical Composition — The percentage contents of carbon, manganese, silicon, sulphur and phosphorus in the deposited weld metal from the all-weld test piece may be reported. The sulphur and phosphorus content shall not exceed 0·05 percent each.

6.4 Transverse Tensile Tests — Two transverse tensile specimens shall be prepared in accordance with the method specified in **1.8.3**.

The tensile strength of each specimen shall be not less than 350 N/mm^2 (36 kgf/mm^2).

6.5 Transverse Bend Test — Four transverse bend specimens shall be prepared and tested in accordance with the method specified in **1.8.5**.

Each test specimen satisfies if bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimens no crack or defect at the outer surface of the specimen is greater than 3 mm measured across the specimen or 1·5 mm along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

SECTION 7 TWO-RUN WELDING : LONGITUDINAL WELD TENSILE STRENGTH 550-700 N/mm² (56-71 kgf/mm²), YIELD STRESS NOT LESS THAN 450 N/mm² (46 kgf/mm²)

7.1 Longitudinal Weld Tensile Test — One longitudinal weld tensile test specimen shall be prepared and tested in accordance with the method specified in **1.8.3.**

The tensile strength of the specimen shall be within the range 550-700 N/mm² (56-71 kgf/mm²) and the yield stress not less than 450 N/mm² (46 kgf/mm²). The elongation shall be not less than 22 percent.

7.2 Butt-Weld Impact Test — Three impact test specimens shall be prepared in accordance with **1.8.6.** The average of the three impact values shall not be less than the following:

Grade	*Average Impact Values (Min)*		*Testing Temperature* °C
	J	kgf.m	
SA 1 T 450	47	4·7	(Room Temp) 20 Approx
SA 2 T 450	47	4·7	0 ± 1
SA 3 T 450	47	4·7	−20 ± 1
SA 4 T 450	47	4·7	−40 ± 1

The results of the impact tests shall be assessed as specified in **7.2.1.**

7.2.1 The average $\bar{x}_3$ of the results of the three tests shall be assessed as follows:

$\bar{x}_3$ J	*Assessment*
Up to and including 40	Requirement *not* fulfilled
Including and over 47	Requirement *fulfilled*

If the value of $\bar{x}_3$ lies between 40 and 47 J, three additional specimens shall be prepared and tested, and the results added to those previously obtained to form a new average $\bar{x}_6$. If the value of $\bar{x}_6$ is 47 J or above the wire-flux combination shall be deemed to have fulfilled the requirements.

If the value of $\bar{x}_6$ is less than 47 J, further six specimens shall be prepared using the same batch of wire and fluxes, if possible, and tested, and the results added to the previous value of $\bar{x}_6$ to form a new average $\bar{x}_{12}$ the value of which shall be not less than 47 J.

7.3 Chemical Composition — The percentage contents of carbon, manganese, silicon, sulphur and phosphorus in the deposited weld metal from the all-weld test piece may be reported. The sulphur and phosphorus content shall not exceed 0·05 percent each.

7.4 Transverse Tensile Tests — Two transverse tensile specimens shall be prepared in accordance with the method specified in **1.8.3.**

The tensile strength of each specimen shall be not less than 450 N/mm² (46 kgf/mm²).

7.5 Transverse Bend Test — Four transverse bend specimens shall be prepared and tested in accordance with the method specified in **1.8.5.**

Each test specimen satisfies if bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimens, no crack or defect at the outer surface of the specimen is greater than 3 mm measured across the specimen or 1·5 mm along the length of the specimen. Premature failure at the corners of the specimens shall not be considered cause of failure.

APPENDIX A

(*Clauses* 1.3.1 *and* 1.8.1.1)

PARENT METAL FOR TEST PLATES

A-1. PARENT METAL

A-1.1 The parent metal used in preparing test piece and test specimen shall be as given in Table 1.

TABLE 1 PARENT METAL FOR TEST PLATES

Section of Standard	Parent Metal Specification	Range of Tensile Strength	
		N/mm²	kgf/mm²
Sections 2, 3, 4 and 5	IS : 226-1969 or IS : 2062-1969	410-510 410-510	42-52 42-52
Section 6	IS : 2041-1962, Type 2	510-610	52-62
Section 7	IS : 961-1962 Grade ST-55W	540-710	55-70

A-1.2 The plates may be in the as-rolled or normalized condition and the chemical composition and tensile strength shall be verified from the test on the plate before the test pieces are prepared. These results should be made available on request.

Although steel complying with the requirements of Table 1 is used for approval purpose, there can be variations in composition within any particular grade. When other steels are used in practice, different properties may be obtained and if the consistency of the properties is important, the user should consult the consumables supplier and should make his own tests to check the suitability of a particular wire-flux combination.

(*Continued from page* 2)

Welding Consumables Subcommittee, SMDC 14 : 1

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Ad-hoc Panel for Wire-Flux Combination for Submerged-Arc Welding SMDC 14 : AP 1

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‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	839 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001	40 36 27
Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No.29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
E-52, Chitaranjan Marg, C- Scheme, JAIPUR 302001	37 29 25
117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
NIT Building, Second Floor, Gokulpat Market, NAGPUR 440010	52 51 71
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