මෙය රාජ්‍ය භාෂාවෙන් වෙනම මුද්‍රණය කර ඇත.

ශ්‍රී ලංකා ප්‍රමිති 414 : 1977

SRI LANKA STANDARD 414 : 1977

විශ්ව දශම වර්ග කිරීම UDC 621·791·753·042·4 : 669·15—194·2

මෘදු වානේ වල අත් ලෝහ චාප වෙල්ඩිම සඳහා වැසි ඉලෙක්ට්‍රෝඩ පිළිබඳ පිරිවිතර

SPECIFICATION FOR COVERED ELECTRODES FOR THE MANUAL METAL ARC WELDING OF MILD STEEL

ලංකා ප්‍රමිති කාර්යාංශය

BUREAU OF CEYLON STANDARDS

SPECIFICATION FOR COVERED ELECTRODES FOR THE MANUAL METAL ARC WELDING OF MILD STEEL

S. L. S. 414 : 1977

Gr. 6

BUREAU OF CEYLON STANDARDS
53, Dharmapala Mawatha,
COLOMBO 3.

SRI LANKA STANDARD SPECIFICATION FOR COVERED ELECTRODES FOR THE MANUAL METAL ARC WELDING OF MILD STEEL

FOREWORD

This Sri Lanka Standard has been prepared by the Drafting Committee of the Bureau on Welding. It was approved by the Mechanical Engineering Divisional Committee of the Bureau of Ceylon Standards and was authorised for adoption and publication by the Council of the Bureau on 1977-05-11.

All values given in this specification are in SI (metric) units.

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 CS 102 : 1971*. The number of significant figures retained in the rounded off value shall be the same as that of the specified value in the standard.

Publications of the International Organisation for Standardisation, the Indian Standards Institution and the Japanese Standards Association have been consulted in the preparation of this specification and the assistance gained therefrom is acknowledged.

1. SCOPE

This specification covers the requirements for covered electrodes of sizes 1 mm and above for manual metal arc welding of mild steel.

2. TERMINOLOGY

For the purpose of this standard the following definitions shall apply.

2.1 Arc welding — Fusion welding in which heat for welding is obtained from an electric arc or arcs.

2.2 Metal arc welding — Arc welding using consumable electrode.

*CS 102 : 1971 — Presentation of Numerical Values.

2.3 Covered electrode — An electrode which provides filler metal and having a covering of flux or other materials.

3. CLASSIFICATION AND CODING

The coding for an electrode shall consist of four parts as follows and as detailed in Appendix A.

(1) General symbol indicating the product to be identified.

(2) A symbol indicating a further identification of the product related to the composition.

(3) A symbol indicating certain mechanical properties.

(4) Symbols indicating the type of covering and the thickness of covering.

4. MATERIAL

The mild steel core wire shall conform to the following requirements.

4.1 The core wire shall be manufactured from steel ingots made by electric furnace, open-hearth furnace, or Linz Donowitz Converter (Basic Oxygen Process Converter).

4.2 Chemical composition :

Constituent	Per cent
Carbon	0·10 max.
Silicon	0·03 max.
Manganese	0·30 to 0·70
Sulphur	0·030 max.
Phosphorus	0·030 max.
Copper	0·15 max.

5. SIZES

5.1 The size of the electrodes shall be designated by the diameter of the core wire expressed in millimetres. The designation and size of the electrodes shall be as given in next page :

Designation of the electrodes size	Diameter of the core wire mm
1	1·00
1·25	1·25
1·6	1·60
2	2·00
2·5	2·50
3·15	3·15
4	4·00
5	5·00
6·3	6·30
8	8·00
10	10·00
12·5	12·50

5.2 **Tolerance on size** — The tolerance on the specified diameter of the core wire of the electrode shall be as given below :

Size of wire mm	Tolerance mm
Up to 8	+0·00 − 0·05
Over 8 up to and including 12·5	+0·00 − 0·10

5.3 **Lengths** — The length of various sizes of electrodes shall be as given below :

Designation of the electrodes size	Length mm
1	200
1·25	200
1·6	200
	250
2	200
	250
	300
	350
2·5	250
	300
	350
above 2·5	350
	450

5.4 Tolerance on length — The tolerance on the length of individual electrodes over nominal length shall be ± 3 mm.

6. GENERAL REQUIREMENTS

6.1 The contact end (holder end) of the electrodes shall be bare and clean to a length of 20 to 30 mm.

6.2 The arc striking end of the electrode shall permit easy striking of arc. Where the end is bare, the distance from the arc end to the first point, where the full cross section of the covering prevails, shall not exceed the diameter of core wire subject to a maximum length of 2·5 mm.

6.3 The flux covering shall comply with the following requirements.

6.3.1 Thickness — The coating on electrodes shall be classified into three categories-thin, medium and heavy in accordance with the thickness of casting as follows :

thin - Overall diameter less than 120 per cent of the diameter of the core wire.

medium - Overall diameter between 120-145 per cent of the diameter of the core wire.

heavy - Overall diameter greater than 145 per cent of the diameter of the core wire.

6.3.2 Uniformity — The covering shall be of such uniformity in outside diameter that it fuses or/and burns evenly.

7. SPECIFIC REQUIREMENTS

7.1 Electrodes shall be subjected to the following tests for assessing the mechanical properties of the deposited weld metal.

(a) All-weld tensile test.

(b) All-weld impact test.

Tensile and impact tests are executed under controlled conditions, on metal deposited from the electrodes.

7.2 All-weld Tensile Test — Two all-weld tensile test specimens shall be prepared and tested in accordance with the method described in Appendix B. The tensile strength and the minimum elongation shall comply with the values given in Table 1.

7.3 All-weld Impact Test— Two sets of three U-notch impact test specimens shall be prepared and tested in accordance with the method described in Appendix B. The testing temperatures shall be as given in Table 1. The average $\bar{x}_3$ of the results of the tests shall be assessed as follows :

$\bar{x}_3$	assessment*
Up to and including 23J	Requirement not fulfilled
Including and over 28J	Requirement fulfilled

If the value of $\bar{x}_3$ lies between 23J and 28J three additional specimens for each set 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 28J or over, the electrodes shall be deemed to have fulfilled the requirements. If $\bar{x}_6$ is less than 28J the requirement is not fulfilled.

TABLE 1 — MECHANICAL PROPERTIES

Electrode Designation	Tensile Strength	Minimum elongation on L = 5d	Temperature for minimum impact value of 28 J*
	MPa**	per cent	°C
E 43 0	430 to 510	—	—
E 43 1	430 to 510	20	+ 27
E 43 2	430 to 510	22	0
E 51 0	510 to 610	—	—
E 51 1	510 to 610	18	+ 27
E 51 2	510 to 610	18	0

upper limits tolerance : +40 MPa

*1 J = 0·102 kgf. m

**1MPa = 0·101972 kgf/mm²

8. PACKING AND STORAGE

8.1 The net mass of an individual bundle or carton of electrodes for manual operation shall not exceed 7 kg.

8.2 Electrodes shall be suitably packed to guard against damage during transportation. The packing shall be suitable to ensure that under normal store room conditions, the electrodes shall, for a period of at least six months after the despatch from the manufacturer's stores, be capable of giving results in accordance with the provisions of this specification and that if the flux covering is of a type requiring special protection during storage, the details of such special protection shall be furnished by the manufacturer and reference to this should be included in the marking of the bundle or box of electrodes. The electrodes shall be stored in a dry store room.

8.3 Each bundle or package shall contain the manufacturer's certificate guaranteeing that the electrodes therein comply with the physical and performance requirements set forth in this standard.

8.3.1 The batch of electrodes represented by the electrodes tested shall not be certified as complying with the specification unless the test results obtained satisfy the requirements specified and the manufacturer has performed tests at intervals in accordance with the requirements of this specification.

9. TEST RESULTS

9.1 On request, as evidence that the electrodes supplied comply with the requirements of this specification, the manufacturer shall produce the results of the most recent periodic check tests carried out within the preceding 12 months on the electrodes representative of the electrodes supplied.

10. MARKING

10.1 Each bundle or package of electrodes shall be clearly marked with the following information.

(a) Code marking ;

(b) Name of manufacturer ;

(c) Trade designation of electrodes ;

(d) Size ;

(e) Batch number (see Note 1) ;

(f) Recommended current range ;

(g) Recommendations for special storage conditions, if required (see Clause 8.2) ; and

(h) Date of manufacture.

Note : For the purpose of this standard, a batch is defined as being of the same dry mix, the same cast number and the same size of wire.

APPENDIX—A

CLASSIFICATION AND CODING OF ELECTRODES

A-1 GENERAL

The coding of electrodes is divided into four parts :

(1) the first part gives a general symbol indicating the product to be identified.

(2) the second part gives a symbol indicating a further identification of the product related to the composition ;

(3) the third part gives a symbol indicating certain mechanical properties ;

(4) the fourth part gives symbols indicating the type of covering, and the thickness of covering.

A-2 SYMBOLS AND REQUIREMENTS

A-2.1 Symbol for the product — The general symbol for electrodes for arc welding is the letter E.

It shall be placed at the beginning of the designation. The purpose of this symbol is to establish a difference between the designation of arc welding electrodes, as a filler metal for welding, and other filler metals for welding, when other power sources are used, like gas welding. For all other processes different from manual arc welding (like gas-metal arc welding) a further symbol is used for a closer identification.

For covered electrodes for manual arc welding, only the symbol E is used.

A-2.2 Symbol for the composition — In general the second part gives a symbol indicating a further identification of the product in relation to composition. However, in this code the composition is not considered and the symbol is based on a division into two ranges of tensile strength of the weld metal determined under the conditions given in Appendix B.

Two ranges of tensile strength are specified, namely :

(1) Tensile strength from 430 to 510 MPa - Symbol 43.

(2) Tensile strength from 510 to 610 MPa - Symbol 51.

In view of possible scatter in welding and testing, the upper limits of 510 and 610 MPa respectively may be exceeded by 40 MPa.

A-2.3 Symbol for the mechanical properties — For each class of tensile strength, a division into three groups has been specified on the basis of U-notch impact values and elongation, established under conditions stated in Appendix B.

Symbols : 0, 1, 2.

Requirements as given in Table 1.

A-2.4 Symbols related to type of covering and the thickness of covering — The last part of the coding comprises two symbols indicating the type of covering and the thickness of covering.

A-2.4.1 The type of covering is symbolized as follows :

Symbol	Type of covering
1	Having a high cellulose content.
2	Having a high content of titania and producing a fairly viscous slag.
3	Containing an appreciable amount of titania and producing a fluid slag.
4	Having a high content of oxides or silicates or both of iron and manganese and producing an inflated slag.
5	Having a high content of iron oxides or silicates or both and producing a heavy solid slag.
6	Having a high content of calcium carbonate and fluoride.

The designations are to be understood as follows :

Symbol 1-Electrode with covering having a high cellulose content

The covering contains at least 15 per cent of material having a high cellulosic content and up to 30 per cent of titania (as rutile or titanium white).

This type of electrode is characterised by a deep penetrating arc and rapid burn-off-rate. Spatter loss is somewhat higher than that with electrodes having the mineral type of covering. A voluminous gas shield is formed as a result of the decomposition of the cellulosic material in the arc region. The weld finish is somewhat coarser than usual, the ripples being rather more pronounced and less evenly spaced. The deposit has a thin cover of slag which is friable and thus easy to remove.

Because of its arc characteristics and the small volume of slag produced, the electrode is particularly easy to use in any welding position. With current values near to the maximum of the range, the electrode may be used in the flat position for 'deep penetration' welding.

The electrode is suitable for all types of mild steel welding and is of particular value for applications involving changes in position of welding, for example, in pipe welding, storage tanks, bridges and ship building.

Generally, this type of electrode is suitable for use with direct current with the electrode connected to the positive pole. Some types are available which contain arc stabilizing materials and are suitable for use with alternating current.

Symbol 2 - Electrode with covering having a high content of titania and producing a fairly viscous slag.

The covering contains a high proportion of titania (as rutile, titanium white or ilmenite) and the high content of ionizers provides excellent welding properties.

Electrode of this type is suitable for butt and fillet welds in all positions and is particularly easy to use for fillet welds in the horizontal - vertical position. Sizes larger than 5 mm are not normally used for vertical and overhead welding. Fillet welds tend to be convex in profile and have medium root penetration. The electrode has smooth arc characteristics and normally produces very little spatter. The slag is dense and completely covers the deposit and is easily detached, except from the first run in a deep V-groove.

The electrode is particularly suitable for use with alternating-current and on direct current it may be used with the electrode connected to either pole.

Symbol 3 - Electrode with covering containing an appreciable amount of titania and producing a fluid slag.

The covering contains an appreciable amount of titania (as rutile, titaniun white or ilmenite), but the addition of basic materials yields a much more fluid slag than that produced by electrodes having the Symbol 2.

The electrode is suitable for use with alternating current and direct current and may be used with the electrode connected to either pole. Welding in the overhead and vertical (upwards) positions is far easier with this type of electrode than with any other type of mild steel electrode, but its use is not confined to those positions. The electrode has smooth arc characteristics medium

penetrations, and normally produces very little spatter. The slag is generally easy to detach, even from the first run in a deep V-groove.

The deposit produced by this type of electrode will usually meet normal radiographic tests more readily than the one made with electrodes having the Symbol 2.

Symbol 4—Electrode with covering having a high content of oxides or silicates or both of iron and manganese and producing an inflated slag.

The covering consists principally of oxides or carbonates of iron and manganese, together with silicates.

The electrode is generally produced with a thick covering and is used for welding in the flat position only. Certain varieties have a thinner covering and these may be used for welding in all positions but have generally been superseded by other types of electrodes. Both the forms of covering produce a fluid, voluminous slag which freezes with a characteristic internal honeycomb of holes, the so-called 'inflated' slag, which is very easily detached. The weld finish is smooth, the ripples being much less pronounced than on deposits produced by the other types of electrodes. In grooves and fillet welds the weld profile is concave. The principal application for this type of electrode with a thick covering is for deep groove welding in thick plates, particularly where such welds are subject to strict radiographic acceptance standards. Certain varieties of this type of electrodes are suitable for 'deep penetration' welding.

The electrode is suitable for use with direct current usually with the electrode connected to the positive pole, and may be used on alternating current.

Symbol 5 - Electrode with covering having a high content of iron oxides or silicates or both and producing a heavy solid slag.

This type of electrode has a thick covering consisting principally of iron oxides with or without oxides or manganese.

Electrode of this type is used principally for single run fillet welds where appearance is of primary importance. The covering melts with a pronounced 'cupped' effect at the electrode tip

enabling the electrode to be used touching the work, this procedure being known as 'touch welding'. The degree of penetration is low. A heavy solid slag is produced which is sometimes 'self detaching', and in fillet welds, gives a smooth concave profile. The electrodes having the symbol 5 are sometimes referred to as 'dead soft' electrodes because the weld metal has low carbon content and a particularly low manganese content. This type of electrode has been used with some success for the welding of certain high-tensile steels and also steels having a higher content of sulphur than those used for structural welding, but on such steels the weld profile may be more irregular.

Weld metal deposited by this type of electrodes usually has low mechanical properties, the reduction of area and Izod impact values being generally less than the values normally specified.

The electrode is particularly suitable for use with alternating current and direct current and may be used with the electrode connected to either pole.

Symbol 6—Electrode with covering having a higher content of calcium carbonate and fluoride.

The covering of this electrode contains appreciable quantities of calcium carbonate and fluoride. The slag is fairly fluid and the deposit is usually convex to flat in profile. This class of electrode is generally suitable for welding in all positions.

Electrodes of this class are also known as 'basic coated' and have the advantage of being particularly suitable for welding medium and high tensile structural steels and other applications where high mechanical properties and maximum resistance to cracking are required. They are also used for welding steels having higher carbon and sulphur contents than normal structural steels.

During manufacture these electrodes are baked at a high temperature and to obtain the best results they should be properly stored, and if necessary, thoroughly dried to the manufacturer's recommendations before use.

In welding with these electrodes it is necessary to use short arc and the correct electrode angle to achieve maximum soundness in the weld deposit. Properly used in this way the electrode will produce welds to high radiographic acceptance standards.

Most of the electrodes recently developed can be used with alternating current but with some types direct current is preferred, in which case the electrode should be connected to the pole recommended by the manufacturer.

Coatings of this type are commonly used for electrodes depositing high tensile and alloy weld metals.

Note: It should be appreciated that the addition of metal powder to any of the above types of covering may affect the characteristics described above.

A-2.4.4. The thickness of covering is symbolized as follows:

Symbol	
t	thin - Overall diameter less than 120 per cent of the diameter of the core wire.
m	medium - Overall diameter between 120 and 145 per cent of the diameter of the core wire.
h	heavy - Overall diameter greater than 145 per cent of the diameter of the core wire.

A-3 Examples for coding of electrodes

(a) Covered electrodes for manual electric arc welding having a covering designated by Symbol 3 of medium thickness and depositing weld metal with the following minimum mechanical properties :

Tensile strength : 500 MPa
Elongation : 23 per cent
Impact strength : 30 J at 27°C

The coding of the electrode in this instance is

E 43 13 m

(b) Covered electrode for manual electric arc welding having a thin covering designated by Symbol 6 and depositing weld metal with the following mechanical properties:

Tensile strength	:	560 MPa
Elongation	:	20 per cent
Impact strength	:	32 J at 0°C

The coding of the electrode in this instance is E 51 26t

APPENDIX—B

MECHANICAL TESTS

B-1 Tensile and impact tests shall be executed under controlled conditions, on metal deposited from the electrodes.

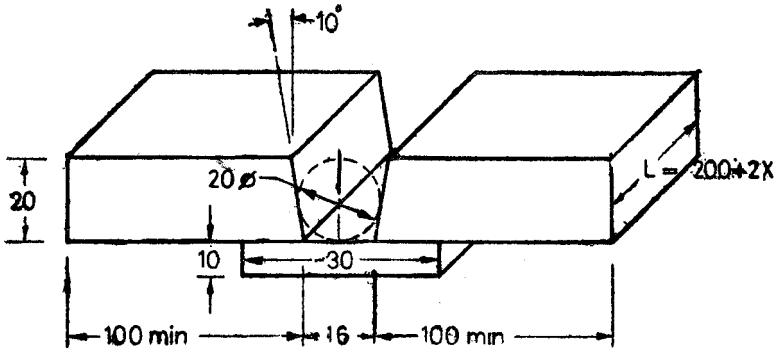
B-1.1 Preparation of the Assembly — The assembly shall be prepared as shown in Figures B-1 and B-2, in the form of a butt joint with a single V-groove with a backing plate 10 mm thick and a root gap of 16 mm. The backing plate shall be tack welded to the test assembly.

In an assembly prepared in this way, the influence of the parent metal is eliminated.

B-1.2 Welding Procedure — Electrodes with a core diameter of preferably 4 mm shall be used. Each pass shall be carried out at normal welding speed and with a welding current specified by manufacturer. If the electrode can be used with both alternating current and direct current, alternating current shall be chosen.

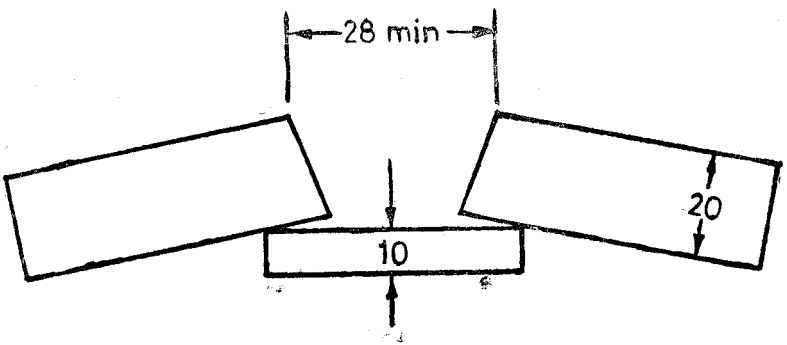
Welding shall be done in the flat position each layer being made up of one or several passes, but each pass shall not be more than 16 mm wide. Each electrode shall be consumed completely (up to a stub end of not more than 50 mm). The direction of deposition of each layer shall alternate from each end of the plate. The reinforcement of the total weld shall not be more than 3 mm.

After each run, the assembly shall be left in still air until it has cooled to a temperature not exceeding 250°C, the temperature being taken on the weld surface midway along the run.



All dimensions in millimetres

Fig. B-1 Dimensions of the test assembly



All dimensions in millimetres

Fig. B-2 Pre-setting of the plates for tack-welding

B-1.3 Deposited metal tensile test piece — The tensile test piece shall be machined to the dimensions shown in Figure B-4, care being taken that the longitudinal axis coincides with the centre of the weld, and the mid-thickness of the plates.

The gauge length of the test piece shall be 50 mm. The ends of the test piece may be of any shape suitable for fixing in the testing machine. The grip length x shall suit the grip of the testing machine.

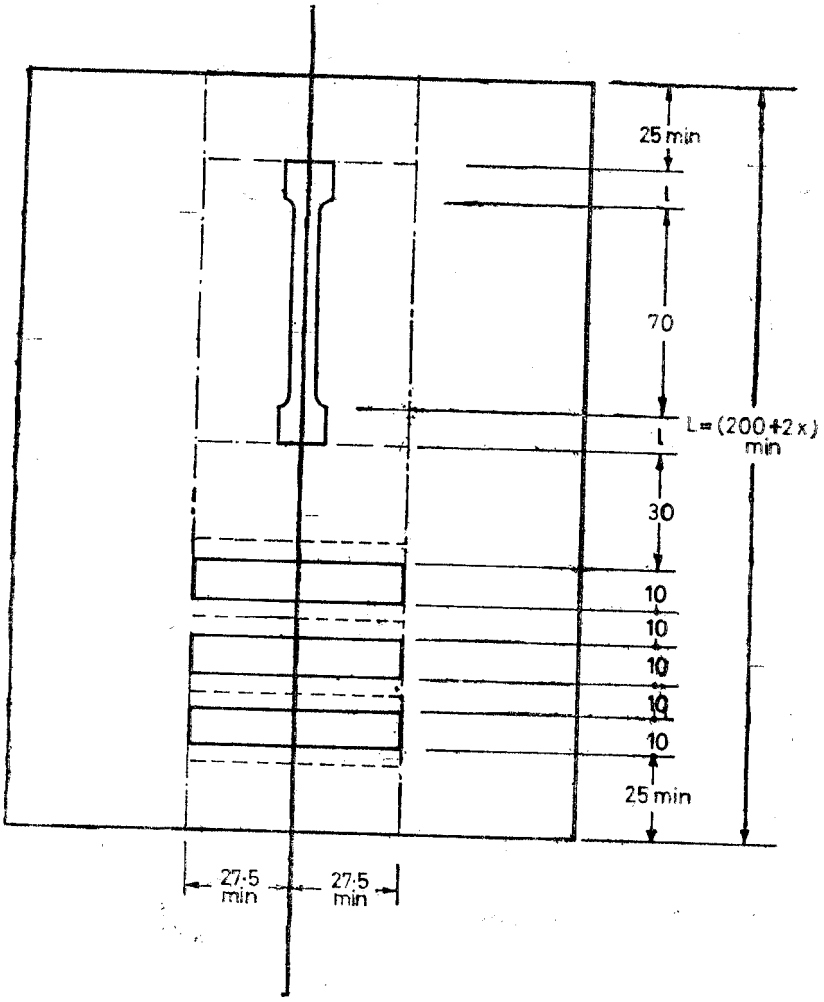
B-1.4 Heat treatment of the tensile test piece — The tensile test piece shall be heat-treated in an electrically heated furnace at 250°C for a period of not less than 6 hours and not more than 16 hours. The purpose of the heat treatment is to remove any hydrogen from the weld metal.

B-1.5 Determination of tensile properties — The tensile strength and the elongation shall be determined at room temperature.

B-1.6 Deposited metal impact test pieces — The impact test pieces shall be of the U-notch type. Three test pieces shall be taken from the test assembly. Their longitudinal axes shall be transverse to the weld and the upper surface 5 mm from the upper surface of the plate.

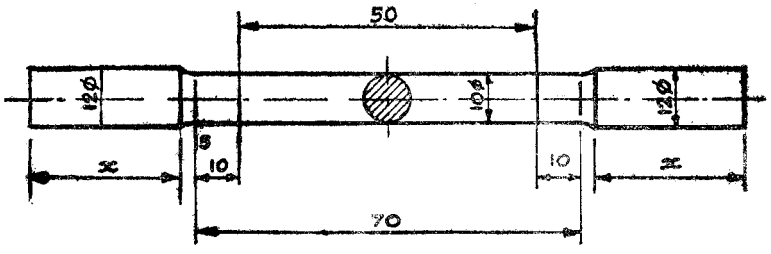
The notch shall be positioned in the centre of the weld and shall be cut in the face of the test piece transverse to the surface of the plate.

All dimensions shall be in accordance with the instructions given in Figures B-5, and shall be carefully checked.



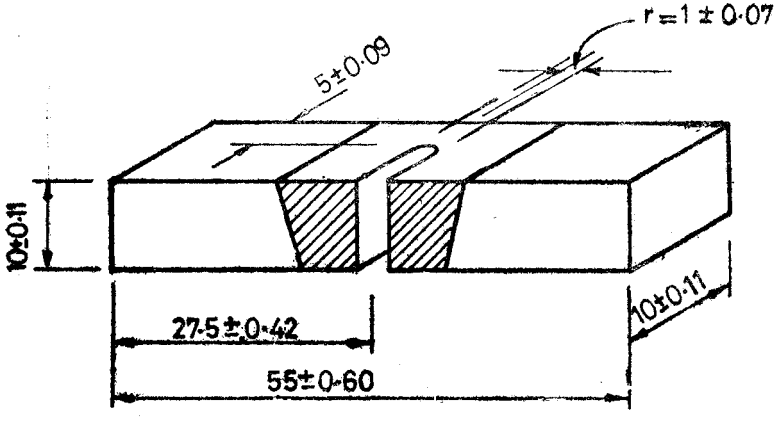
All dimensions in millimetres

Fig. B-3 Position and cutting of test pieces



All dimensions in millimetres

Fig. B-4 All-weld tensile test piece



All dimensions in millimetres

Fig. B-5 Impact Test Piece

SLS CERTIFICATION MARK

The Sri Lanka Standards Institution is the owner of the registered certification mark shown below. Beneath the mark, the number of the Sri Lanka Standard relevant to the product is indicated. This mark may be used only by those who have obtained permits under the SLS certification marks scheme. The presence of this mark on or in relation to a product conveys the assurance that they have been produced to comply with the requirements of the relevant Sri Lanka Standard under a well designed system of quality control inspection and testing operated by the manufacturer and supervised by the SLSI *which includes surveillance inspection of the factory, testing of both factory and market samples.*

Further particulars of the terms and conditions of the permit may be obtained from the Sri *Lanka Standards Institution, 17, Victoria Place, Elvitigala Mawatha, Colombo 08.*

Printed at SLSI (Printing Unit)

SRI LANKA STANDARDS INSTITUTION

The Sri Lanka Standards Institution (SLSI) is the National Standards Organization of Sri Lanka established under the Sri Lanka Standards Institution Act No. 6 of 1984 which repealed and replaced the Bureau of Ceylon Standards Act No. 38 of 1964. The Institution functions under the Ministry of Science & Technology.

The principal objects of the Institution as set out in the Act are to prepare standards and promote their adoption, to provide facilities for examination and testing of products, to operate a Certification Marks Scheme, to certify the quality of products meant for local consumption or exports and to promote standardization and quality control by educational, consultancy and research activity.

The Institution is financed by Government grants, and by the income from the sale of its publications and other services offered for Industry and Business Sector. Financial and administrative control is vested in a Council appointed in accordance with the provisions of the Act.

The development and formulation of National Standards is carried out by Technical Experts and representatives of other interest groups, assisted by the permanent officers of the Institution. These Technical Committees are appointed under the purview of the Sectoral Committees which in turn are appointed by the Council. The Sectoral Committees give the final Technical approval for the Draft National Standards prior to the approval by the Council of the SLSI.

All members of the Technical and Sectoral Committees render their services in an honorary capacity. In this process the Institution endeavours to ensure adequate representation of all view points.

In the International field the Institution represents Sri Lanka in the International Organization for Standardization (ISO), and participates in such fields of standardization as are of special interest to Sri Lanka.

Printed at the Sri Lanka Standards Institution, 17, Victoria Place, Elvitigala Mawatha, Colombo 08.