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British Standard Specification for

Electrode wires and fluxes for the submerged arc welding of carbon steel and medium-tensile steel

Fils-électrodes et flux pour soudage à l'arc sous flux en poudre des aciers au carbone et des aciers à résistance moyenne à la traction — Spécifications

Schweißdrähte und Schweißpulver für das Unterpulverschweißen von unlegiertem Stahl und von Stahl mit mittlerer Zugfestigkeit

British Standards Institution

Foreword

This British Standard, prepared under the direction of the Welding Standards Committee, supersedes BS 4165 : 1971 which is withdrawn. It is the second revision since the standard was published in 1967. This present revision extends the scope of the standard to cover the welding of steels such as those introduced in BS 4360 and includes weld impact values appropriate to these steels.

The results of Charpy V-notch impact tests are known to be affected by many factors. Amongst these are the composition of the welding wire and the type of welding flux, the effect of dilution from the parent material, the heat input of the weld which in turn is affected by the welding current, arc voltage and travel speed, and the disposition of the weld runs in a multi-run weld. For this reason it is usual to carry out tests to assess the mechanical properties on all-weld metal test pieces deposited under defined parameters and thus unaffected by the parent metal used in the preparation of the tests.

The submerged arc process can be used to make butt welds by a two-run technique, one run from each side of the joint, with either square or partially bevelled edges with a generous root face. Such are the penetrating properties with this process that a sound weld can be obtained without resort to back gouging. The weld metal deposited in this manner is heavily diluted with parent plate and is likely to provide significantly different properties to that deposited by a multi-run technique which results in low dilution and provides essentially all-weld metal results. To cater for these differences in technique this standard specifies initial weld tests for both multi-run and two-run deposition. These tests are carried out using specified wire sizes and conditions with an appropriate grade of BS 4360 plate. Testing of these welded joints comprises tensile, bend and Charpy V-notch tests and chemical analysis.

It is important to appreciate that, whilst the tests using the two-run technique give results which approximate to those obtained in practice when welds are carried out under the same conditions with equivalent plate material, the test results obtained from the all-weld metal test pieces with the multi-run technique may not relate to a production type joint. Nevertheless, the tests specified are suitable for grading the results obtained from various wire/flux combinations and enable the fabricator to select a combination which may be appropriate to his production requirements, having regard to the fact that Charpy results from the approval tests may not be representative of those obtained from production joints.

In view of the factors which affect the results obtained from a production situation, it will be advisable for the fabricator to carry out a welding procedure test and reference should be made to BS 4870 : Part 1.

On completion of testing, the wire/flux combination is assigned the appropriate grading code which takes the form of a prefix number related to the impact test temperature, followed by the letters M and/or T to indicate multi-run, two-run or both and finally a three figure number related to tensile properties of the weld metal. For example, a wire/flux combination giving weld metal in a two-run test with an average impact value better than 35 J at −40 °C, a tensile strength in the range 400 N/mm^2 to 600 N/mm^2 and yield stress above 300 N/mm^2, would have the grading 4T300.

Manufacturers usually supply a range of wires and fluxes. This standard includes a table of the commonly used wire analyses and a descriptive table of the various types of welding flux. Fluxes are based on various combinations of compounds and the ratio of basic to acidic components in a flux is known as the Basicity Index.

Generally high basicity fluxes tend to give the best impact properties, other factors being equal. This is a complex subject and in all cases where weld metal toughness is important, the user is advised to consult the consumable supplier 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.

Although combinations of wires and fluxes supplied by individual companies may have the same grading, the individual wires and fluxes from different companies are not necessarily interchangeable.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Contents

Specification

1 Scope

This British Standard specifies requirements for solid electrode wires and for fluxes for the submerged arc welding of carbon steel and medium-tensile steel having a tensile strength of not more than 700 N/mm^2, and sulphur and phosphorus contents of not greater than 0.06 % each. The standard specifies general requirements for all wires and fluxes.

Additionally, clause **12** specifies the initial test requirements for wires and fluxes for use with the multi-run technique while clause **13** specifies the initial test requirements for wires and fluxes for use with the two-run technique.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this standard the definitions given in BS 499 : Part 1 apply together with the following.

2.1 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.

2.2 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.

3 Size of wire

The size of a wire shall refer to the nominal diameter of the wire and shall be expressed in millimetres.

The nominal diameters of wires shall be:

mm
1.6
2.0
2.5
3.0
3.2
4.0
5.0
6.0
6.3

4 Tolerance on diameter of wire

The tolerance on wire diameter shall be ± 3 % of the specified nominal diameter or ± 0.1 mm, whichever is the smaller.

5 Condition of wire

5.1 Finish

The wire shall have a smooth finish, free from surface imperfections, corrosion products, grease or other substances which would adversely affect the quality of the weld or the operation of the welding equipment.

5.2 Coating

If the wire has a copper or nickel coating it shall be a uniform, well-bonded, smooth coating applied over a thoroughly clean surface. The copper content of a copper coated wire, expressed as a percentage of the wire plus the coating, shall not exceed 0.4 % by mass. For nickel coated wires the total nickel content of the wire plus coating shall not be increased by more than 0.2 % by mass.

5.3 Tensile strength

The tensile strength of the wire shall not exceed 930 N/mm^2 for carbon steel and shall not exceed 1080 N/mm^2 for medium-tensile steel.

NOTE. Wires having higher values of tensile strength may be supplied by agreement between the purchaser and manufacturer.

6 Composition of wire

The chemical composition of the wire shall correspond with one of those given in table 1.

NOTE. The composition of certain other ferritic steel submerged arc wires are included in appendix A. It is not intended that these wires be subjected to the tests or grading specified in this standard.

Table 1. Wire composition (% by mass)

Type	Designation	C		Mn		Si		S	P	Ni*		Cr	Mo		Cu*	Al	Sn
		min.	max.	min.	max.	min.	max.	max.	max.	min.	max.	max.	min.	max.	max.	max.	max.
C-Mn	S1	0.04	0.12	0.40	0.65		0.10	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S1 Si	0.04	0.12	0.40	0.65	0.05	0.20	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S2	0.06	0.15	0.80	1.20		0.10	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S2 Si	0.06	0.15	0.80	1.20	0.10	0.35	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S3	0.06	0.15	1.30	1.80		0.25	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S3 Si	0.06	0.15	1.30	1.80	0.15	0.40	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S4	0.07	0.16	1.80	2.20		0.25	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
	S4 Si	0.07	0.16	1.80	2.20	0.10	0.35	0.03	0.03		0.15	0.15		0.15	0.15	0.04	0.03
Mn-Ni	S2-1Ni	0.05	0.12	0.80	1.20	0.05	0.30	0.02	0.02	0.75	1.25	0.15		0.15	0.15	0.04	0.03
	S2-1½Ni	0.05	0.12	0.80	1.20	0.05	0.30	0.02	0.02	1.25	1.75	0.15		0.15	0.15	0.04	0.03
	S2-2Ni	0.05	0.12	0.80	1.20	0.05	0.30	0.02	0.02	1.75	2.25	0.15		0.15	0.15	0.04	0.03
	S2-2½Ni	0.05	0.12	0.80	1.20	0.05	0.30	0.02	0.02	2.25	2.75	0.15		0.15	0.15	0.04	0.03
	S2-3Ni	0.05	0.12	0.80	1.20	0.05	0.30	0.02	0.02	2.75	3.25	0.15		0.15	0.15	0.04	0.03
	S3-1Ni	0.05	0.12	1.30	1.70	0.05	0.30	0.02	0.02	0.75	1.25	0.15		0.15	0.15	0.04	0.03
	S3-1½Ni	0.05	0.12	1.30	1.70	0.05	0.30	0.02	0.02	1.25	1.75	0.15		0.15	0.15	0.04	0.03
NiMo	S2-1NiMo	0.07	0.15	0.80	1.20	0.05	0.30	0.02	0.02	0.75	1.25	0.15	0.10	0.50	0.15	0.04	0.03
	S3-1NiMo	0.07	0.15	1.30	1.80	0.05	0.30	0.02	0.02	0.75	1.25	0.15	0.45	0.65	0.15	0.04	0.03
	S3-1½NiMo	0.07	0.15	1.30	1.80	0.05	0.30	0.02	0.02	1.25	1.75	0.15	0.45	0.65	0.15	0.04	0.03
	S4-1NiMo	0.10	0.17	1.80	2.20	0.05	0.30	0.02	0.02	0.75	1.10	0.15	0.45	0.65	0.15	0.04	0.03
Mn-Mo	S1 Mo	0.07	0.15	0.40	0.65	0.05	0.30	0.025	0.025		0.15	0.15	0.45	0.65	0.15	0.04	0.03
	S2 Mo	0.07	0.15	0.80	1.20	0.05	0.30	0.025	0.025		0.15	0.15	0.45	0.65	0.15	0.04	0.03
	S3 Mo	0.07	0.15	1.30	1.70	0.05	0.30	0.025	0.025		0.15	0.15	0.45	0.65	0.15	0.04	0.03
	S4 Mo	0.07	0.15	1.70	2.20	0.05	0.30	0.025	0.025		0.15	0.15	0.45	0.65	0.15	0.04	0.03

* Excluding coating if any.

7 Coils

Wire shall be supplied in coils or pay-off packs having dimensions and masses as given in table 2.

8 Coiling conditions

The wire shall be wound evenly in one continuous length and shall be free from kinks, waves, sharp bends or twists, so that it is free to unwind without restriction.

The starting end of the wire on each coil shall be clearly indicated.

9 Flux

The flux shall be free flowing and when used in conjunction with an appropriate wire and in accordance with the manufacturer's recommendations, shall have such characteristics as to produce welds having acceptable contour, appearance and penetration.

Appendix B provides guidance on flux types and characteristics.

10 Testing and grading

The wires and fluxes shall be capable of complying in all respects with the appropriate requirements and tests in this standard. In particular wire and flux combinations which are suitable for multi-run, two-run techniques or both shall be tested initially in accordance with the tests in clauses **12** and **13**, as appropriate. Wire-flux combinations suitable for use on either a.c. or d.c. shall be tested on a.c. In all cases the type of current used in the tests shall be reported.

On satisfactory completion of these tests the flux and wire combinations shall be graded as complying with this standard using the grades listed under clauses **12** and **13**. The grade number is made up of three parts: a prefix number related to impact testing temperature, the letters M or T indicating multi- or two-run techniques and a three figure suffix related to minimum yield stress in N/mm^2, e.g.:

Grade 2	M	350
Test temperature of 0 °C	Multi-run	Minimum yield stress of 350 N/mm^2 (tensile strength 460 N/mm^2 to 650 N/mm^2)

Where both M and T gradings are approved for a particular wire/flux combination the grade numbers shall be given separately, e.g.:

3M450/1T450

11 Initial tests

These comprise the initial tests to which each type of wire and flux shall be subjected. Although it is not expected that every batch of wire and flux will be subjected to the initial tests the manufacturer shall ensure that every batch is capable of passing the whole of the test requirements.

NOTE. The purchaser may require that some or all of the tests are carried out on batches supplied to him (see clause **14**).

Table 2. Dimensions of coils and pay-off packs of wire

Outer diameter (max.)	Inner diameter of bound coil with no former	Inner diameter of bound former	Width (max.)	Depth (max.)	Mass of wire (max.)
mm	mm	mm	mm	mm	kg
Coils					
300	200^{+5}_{0}	200^{+1}_{0}	90	–	13
420	300^{+5}_{0}	300^{+1}_{0}	80	–	25
420	300^{+5}_{0}	300^{+1}_{0}	100	–	30
420	300^{+5}_{0}	300^{+1}_{0}	115	–	30
760	610 ± 10	610 ± 10	100	–	70
760	610 ± 10	610 ± 10	100	–	100
760	610 ± 10	610 ± 10	150	–	100
Pay-off packs					
600	–	–	–	900	400

12 Initial test requirements for multi-run technique

12.1 All-weld tensile test

Two all-weld tensile test specimens, one using 3.2 mm or less diameter wire and one using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix D. The tensile strength, yield stress and elongation shall comply with the appropriate grade requirements.

12.2 All-weld impact test

Six Charpy V-notch impact test specimens, three using 3.2 mm or less diameter wire and three using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix D. The test results shall comply with the appropriate grade requirements.

If the average of the three impact values from either set of specimens fails to comply with the requirements by an amount not exceeding 15 % of the required value, the test shall be repeated on a further set of three specimens taken from the original test piece and the results added to those previously obtained to form a new average which shall comply with the requirements.

When the average of the three impact values from either set of specimens is more than 15 % below the required value, the requirements of clause **15** shall apply.

12.3 Chemical composition*

The percentage contents of carbon, manganese, silicon, sulphur, phosphorus, nickel†, molybdenum† and copper in the deposited weld metal from the all-weld test piece shall be reported. The sulphur and phosphorus contents shall comply with the appropriate grade requirements.

12.4 Transverse tensile test

Two transverse tensile test specimens, one using 3.2 mm or less diameter wire and one using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix E.

The tensile strength of each test specimen shall comply with the appropriate grade requirements.

12.5 Transverse bend test

Four transverse bend test specimens, two using 3.2 mm or less diameter wire and two using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix E. One specimen of each pair shall be tested with the face of the weld in tension and the other specimen with the root of the weld in tension.

Specimens shall satisfy 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 measured across the test specimen or 1.6 mm measured along the length of the test specimen. Premature failure at the corners of the test specimen shall not be considered cause for rejection.

12.6 Requirements for M300 grades

The test results for M300 grades shall comply with table 3 as appropriate.

Table 3. M300 grade requirements

Grade	All-weld tensile test			All-weld impact test		All-weld test piece composition		Transverse tensile strength (min.)
	Tensile strength	Yield stress (min.)	Elongation (min.)	Minimum impact value (average of three values)	Testing temperature	Sulphur (max.)	Phosphorus (max.)	
	N/mm^2	N/mm^2	%	J	°C	%	%	N/mm^2
1M300	400 to 600	300	22	35	20 approx.	0.05	0.05	400
2M300	400 to 600	300	22	35	0 ± 1	0.05	0.05	400
3M300	400 to 600	300	22	35	−20 ± 1	0.05	0.05	400
4M300	400 to 600	300	22	35	−40 ± 1	0.05	0.05	400
5M300	400 to 600	300	22	35	−50 ± 1	0.05	0.05	400
6M300	400 to 600	300	22	35	−60 ± 1	0.05	0.05	400

* See BS Handbook No. 19.

† Where appropriate.

12.7 Requirements for M350 grades

The test results for M350 grades shall comply with table 4 as appropriate.

Table 4. M350 grade requirements

Grade	All-weld tensile test			All-weld impact test		All-weld test piece composition		Transverse tensile strength (min.)
	Tensile strength	Yield stress (min.)	Elongation (min.)	Minimum impact value (average of three values)	Testing temperature	Sulphur (max.)	Phosphorus (max.)	
	N/mm^2	N/mm^2	%	J	°C	%	%	N/mm^2
1M350	460* to 650	350	22	40	20 approx.	0.05	0.05	500
2M350	460* to 650	350	22	40	0 ± 1	0.05	0.05	500
3M350	460* to 650	350	22	40	−20 ± 1	0.05	0.05	500
4M350	460* to 650	350	22	40	−40 ± 1	0.05	0.05	500
5M350	460* to 650	350	22	40	−50 ± 1	0.05	0.05	500
6M350	460* to 650	350	22	40	−60 ± 1	0.05	0.05	500

* 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.

12.8 Requirements for M450 grades

The test results for M450 grades shall comply with table 5 as appropriate.

Table 5. M450 grade requirements

Grade	All-weld tensile test			All-weld impact test		All-weld test piece composition		Transverse tensile strength (min.)
	Tensile strength	Yield stress (min.)	Elongation (min.)	Minimum impact value (average of three values)	Testing temperature	Sulphur (max.)	Phosphorus (max.)	
	N/mm^2	N/mm^2	%	J	°C	%	%	N/mm^2
1M450	520* to 700	450	19	45	20 approx.	0.04	0.04	550
2M450	520* to 700	450	19	45	0 ± 1	0.04	0.04	550
3M450	520* to 700	450	19	45	−20 ± 1	0.04	0.04	550
4M450	520* to 700	450	19	45	−40 ± 1	0.04	0.04	550
5M450	520* to 700	450	19	45	−50 ± 1	0.04	0.04	550
6M450	520* to 700	450	19	45	−60 ± 1	0.04	0.04	550

* 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.

13 Initial test requirements for two-run technique

13.1 Longitudinal weld tensile test*

Two tensile test specimens, one using 3.2 mm or less diameter wire and one using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix F. The tensile strength, yield stress and elongation shall comply with the appropriate grade requirements.

13.2 Impact test

Six Charpy V-notch impact test specimens, consisting wholly of deposited metal in the region of the notch, three using 3.2 mm or less diameter wire and three using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix F. The test results shall comply with the appropriate grade requirements.

If the average of the three impact values from either set of specimens fails to comply with the requirements by an amount not exceeding 15 % of the required value, the test shall be repeated on a further set of three specimens taken from the original test piece and the results added to those previously obtained to form a new average which shall comply with the requirements.

When the average of the three impact values from either set of specimens is more than 15 % below the required value, the requirements of clause **15** shall apply.

13.3 Transverse tensile test

Two transverse tensile test specimens, one using 3.2 mm or less diameter wire and one using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix F.

The tensile strength of each test specimen shall comply with the appropriate grade requirements.

13.4 Transverse bend test

Four transverse bend test specimens, two using 3.2 mm or less diameter wire and two using the largest size of wire submitted for approval, shall be prepared and tested in accordance with appendix F. One specimen from each test piece shall be tested with the first side welded in tension and one specimen with the second side welded in tension.

Specimens shall satisfy 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 measured across the test specimen or 1.6 mm measured along the length of the test specimen. Premature failure at the corners of the test specimen shall not be considered cause for rejection.

13.5 Chemical composition†

An all-weld test piece of the form shown in figure 1 shall be prepared for the purpose of obtaining the chemical composition of the deposited weld metal. The percentage contents of carbon, manganese, silicon, sulphur and phosphorus shall be reported. The sulphur and phosphorus contents shall comply with the appropriate grade requirements.

13.6 Requirements for T300 grades

The test results for T300 grades shall comply with table 6 as appropriate.

Table 6. T300 grade requirements

Grade	Longitudinal weld tensile test			Impact test		Transverse tensile strength (min.)	All-weld test piece composition	
	Tensile strength	Yield stress (min.)	Elongation (min.)	Minimum impact value (average of three values)	Testing temperature		Sulphur (max.)	Phosphorus (max.)
	N/mm²	N/mm²	%	J	°C	N/mm²	%	%
1T300	400 to 600	300	22	35	20 approx.	400	0.05	0.05
2T300	400 to 600	300	22	35	0 ± 1	400	0.05	0.05
3T300	400 to 600	300	22	35	−20 ± 1	400	0.05	0.05
4T300	400 to 600	300	22	35	−40 ± 1	400	0.05	0.05

* This test is not required if the particular wire/flux combination is also submitted and approved for use with the multi-run technique. The results obtained from this test should not be compared with the results from an all-weld tensile test prepared by the multi-run technique.

† This test is not required if the particular wire/flux combination is also submitted for approval for use with the multi-run technique. See BS Handbook No. 19.

13.7 Requirements for T350 grades

The test results for T350 grades shall comply with table 7 as appropriate.

Table 7. T350 grade requirements

Grade	Longitudinal weld tensile test			Impact test		Transverse tensile strength (min.)	All-weld test piece composition	
	Tensile strength	Yield stress (min.)	Elongation (min.)	Minimum impact value (average of three values)	Testing temperature		Sulphur (max.)	Phosphorus (max.)
	N/mm^2	N/mm^2	%	J	°C	N/mm^2	%	%
1T350	500 to 650	350	22	40	20 approx.	500	0.05	0.05
2T350	500 to 650	350	22	40	0 ± 1	500	0.05	0.05
3T350	500 to 650	350	22	40	−20 ± 1	500	0.05	0.05
4T350	500 to 650	350	22	40	−40 ± 1	500	0.05	0.05

13.8 Requirements for T450 grades

The test results for T450 grades shall comply with table 8 as appropriate.

Table 8. T450 grade requirements

Grade	Longitudinal weld tensile test			Impact test		Transverse tensile strength (min.)	All-weld test piece composition	
	Tensile strength	Yield stress (min.)	Elongation (min.)	Minimum impact value (average of three values)	Testing temperature		Sulphur (max.)	Phosphorus (max.)
	N/mm^2	N/mm^2	%	J	°C	N/mm^2	%	%
1T450	550 to 700	450	19	45	20 approx.	550	0.04	0.04
2T450	550 to 700	450	19	45	0 ± 1	550	0.04	0.04
3T450	550 to 700	450	19	45	−20 ± 1	550	0.04	0.04
4T450	550 to 700	450	19	45	−40 ± 1	550	0.04	0.04

14 Quality control *

The manufacturer shall have a quality control system to ensure that all wire and flux supplied satisfy the requirements of this standard. The system shall be documented and provide for the ready detection of discrepancies and for timely and positive corrective action. The system shall provide records such that the identification number of each batch of wire and flux shall provide references to the manufacturer's own documented records.

Tests and inspections shall be performed during manufacture so that continuous quality control of production is maintained and any departure from the accepted quality will be detected before despatch. From each batch of wire or flux a sufficient quantity of finished material shall be taken to allow execution of the quality control tests defined in the manufacturer's system.

At the time of placing the order, the purchaser shall indicate whether he requires additional tests to be made or certificates to be provided for each batch of wire or flux supplied. If so, the tests and batch definition shall be agreed between the purchaser and the manufacturer.

* Further guidance on general principles may be obtained from BS 4891.

15 Retests

When initial test requirements are not satisfied, two further test pieces shall be prepared, using wire and flux from the same batches and submitted to the test in which failure occurred. Provided that the tests of both of the additional specimens are satisfactory, the wire/flux combination shall be deemed to have passed the test.

16 Packing and storage

16.1 Wire

Wire shall be suitably packed to guard against damage, including that during transportation.

NOTE. When stored, the wire should be kept in its original bundle or package under storage conditions recommended by the manufacturer.

16.2 Flux

Flux shall be packed in moisture-resistant containers and shall be protected from damage, including that during transportation.

NOTE. When stored, the flux should be kept in its original container under storage conditions recommended by the manufacturer.

16.3 Special conditions

If the composition of the flux or condition of the wire is such that special protection during storage or special treatment before use is desirable, the manufacturer shall give details of such special protection or treatment on the package.

17 Marking

17.1 Health warning*

Each coil, pack or container shall be clearly labelled with the following precautionary warning and warning sign.

FUMES AND GASES CAN BE DANGEROUS TO YOUR HEALTH. ARC RAYS CAN INJURE EYES AND BURN SKIN. ELECTRIC SHOCK CAN KILL.

READ AND UNDERSTAND THE MANUFACTURER'S INSTRUCTIONS AND YOUR EMPLOYER'S SAFETY PRACTICES.

17.2 Wires

Each coil or pack of wire and its outer packing shall be clearly marked with the following information (see also clause **18**):

(a) the number and date of this British Standard, i.e. BS 4165 : 1984†, and designation according to table 1;

(b) name of manufacturer;

(c) trade designation of wire;

(d) size and mass of wire;

(e) batch number (see clause **14**);

(f) recommendations for special storage conditions, if required (see **16.3**).

17.3 Flux

Each container of flux shall be clearly marked with the following information (see also clause **18**):

(a) the number and date of this British Standard, i.e. BS 4165 : 1984†;

(b) name of manufacturer;

(c) trade designation of flux;

(d) net mass of flux;

(e) suitability for a.c. or d.c. or both;

(f) batch number (see clause **14**);

(g) recommendations for special storage conditions, if required (see **16.3**).

18 Manufacturer's certificate

This certificate is the manufacturer's assurance that production control tests have ensured that the wires comply with this standard.

On request, as evidence that the wires and fluxes supplied comply with the requirements of this standard, the manufacturer shall produce the results of the most recent check tests carried out within the preceding 12 months on wires and fluxes representative of the wires and fluxes supplied. (See also clause **14**.)

If a test certificate giving the results of the initial tests carried out on the type of wire and flux supplied is requested, it shall be made available by the manufacturer. (See clauses **12** and **13**.)

NOTE. Manufacturers of wire and flux combinations which comply with this standard should provide on request current lists of their product range with grading compliances. Additionally they should provide guidance on the properties likely to be achieved in circumstances where dilution with parent metal is significantly different from that in the tests carried out to this standard.

* See appendix G.

† Marking BS 4165 : 1984 on or in relation to a product is a claim by the manufacturer that the product has been manufactured to the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility. Enquiries as to the availability of third party certification to support such claims should be addressed to the Director, Quality Assurance Division, BSI, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ for certification marks administered by BSI or to the appropriate authority for other certification marks.

Appendix A Composition of other ferritic submerged arc wires (% by mass)

Type	Designation	C min.	C max.	Mn min.	Mn max.	Si min.	Si max.	S max.	P max.	Ni* min.	Ni* max.	Cr min.	Cr max.	Mo min.	Mo max.	Cu* max.	Al max.	Sn max.	V min.	V max.	W min.	W max.
NiCrMo	S2-NiCrMo	0.06	0.12	0.80	1.20	0.05	0.30	0.02	0.02	0.80	1.20	0.80	1.20	0.45	0.65	0.15	0.04	0.03				
	S3-2½NiCrMo	0.06	0.12	1.30	1.70	0.05	0.30	0.02	0.02	2.25	2.75	0.60	0.90	0.45	0.65	0.15	0.04	0.03				
CrMo	S1-1CrMo	0.06	0.14	0.40	0.70	0.05	0.30	0.02	0.02		0.15	1.20	1.70	0.45	0.65	0.15	0.04	0.03				
	S1-2CrMo	0.06	0.14	0.40	0.70	0.05	0.30	0.02	0.02		0.15	2.40	2.80	0.90	1.10	0.15	0.04	0.03				
	S1-5CrMo	0.06	0.14	0.40	0.70	0.25	0.50	0.02	0.02		0.15	4.50	6.00	0.45	0.65	0.15	0.04	0.03				
	S2-1CrMo	0.06	0.14	0.80	1.20	0.05	0.30	0.02	0.02		0.15	1.20	1.70	0.45	0.65	0.15	0.04	0.03				
	S2-2CrMo	0.06	0.14	0.80	1.20	0.05	0.30	0.02	0.02		0.15	2.40	2.80	0.90	1.10	0.15	0.04	0.03				
	S2-5CrMo	0.06	0.14	0.80	1.20	0.20	0.50	0.02	0.02		0.15	4.50	6.00	0.45	0.65	0.15	0.04	0.03				
	S2-9CrMo	0.06	0.12	0.50	1.50	0.25	0.60	0.02	0.02		0.15	8.00	10.0	0.90	1.20	0.15	0.04	0.03				
	S2-12CrMoVW	0.20	0.30	0.80	1.20	0.05	0.40	0.02	0.02		0.80	10.5	12.5	0.80	1.20	0.15			0.20	0.40	0.40	0.60

* Excluding coating if any.

Appendix B Submerged arc welding fluxes: types and characteristics

B.1 Submerged arc welding

The process involves an arc being struck, beneath a flux burden, between a continuous electrode wire and the workpiece. A cavity, filled with a protective gaseous medium derived from decomposition of the flux, is formed around the arc and maintained by a combination of arc forces, and the surface tension and viscosity of the molten flux. Variations of the process may take the form of using more than one wire to give multi-power submerged arc welding (tandem-arc, twin-arc, etc.). In general, these variations are adopted to obtain higher weld metal deposition rate. A similar effect can be achieved through the introduction of separate additional wire(s) to the weld pool, either 'cold' or 'hot', i.e. electrically resistance heated. Deposition rate may also be increased by the addition of metallic iron power either mixed-in, or separately beneath the flux.

B.2 Fused fluxes

These are manufactured by fusing together a mixture of finely ground raw materials. The molten product is quenched, crushed and sieved to the requisite grain size. Generally, fused fluxes show extremely good chemical homogeneity and grain strength. Fine particles, formed during transport or re-cycling during welding, do not cause a change in the chemical composition of the flux. The un-spent flux collected after welding may be used again without significant changes to the grain size range or flux performance.

Fused fluxes have the added advantage that, during storage and use, moisture does not become chemically bonded, only being absorbed on the grain surface. Where necessary, this can be readily removed by re-drying at approximately 150 °C.

A major limitation of fused fluxes is that deoxidants and ferro-alloys cannot be incorporated before fusion since oxidation at the high temperatures used would result in complete loss of both. Additions to the flux after fusion are also unsatisfactory since segregation leads to loss of compositional homogeneity in the weld deposit.

B.3 Agglomerated fluxes

These are manufactured by initially dry mixing several finely ground raw materials. Bonding agents, e.g. sodium and potassium silicates, are added and the wet mix agglomerated to form small granules. These are then furnace baked at a temperature *below* the fusion temperatures of the ingredients and sieved to give the final product grain size.

The agglomeration technique permits the extensive incorporation of deoxidants and ferro-alloys and provides the manufacturer with the greater degree of formulation flexibility essential to the achievement of special performance and weld metal qualities. Fluxes may also be colour coded, by the addition of pigments to the mix. The lower bulk density permits the use of a thicker flux layer which reduces arc instability at lower travel speeds.

This type of flux is sensitive to moisture absorption and requires close control during use and may require a higher re-drying temperature than for fused fluxes.

B.4 Other/specialized fluxes

To achieve special properties or welding behaviour, some variations on the fused and agglomerated manufacturing routes may be encountered. Some fused fluxes are produced by a technique which aerates the melt to give inflated pumice-like granules having lower bulk density. 'Dressed' fluxes are also available in which the grains are coated with a thin layer of different composition to the bulk. Simple mechanical mixtures of two or more fluxes are also produced to cater for special requirements.

B.5 Flux classification

For the purposes of general identification, fluxes may be classified on the basis of their chemical composition. Similarly, the concept of Basicity Index (BI) may be used to create some numerical ranking. Whilst a number of formulae have been put forward for expressing the chemical nature of submerged arc welding fluxes, in the form of a ratio:

$$\frac{\text{Total \% basic oxides}}{\text{Total \% acid oxides}}$$

to obtain a Basicity Index, the following is one of the more widely recognized and used:

$$BI = \frac{CaO + MgO + BaO + SrO + Na_2O + K_2O + Li_2O + CaF_2 + \tfrac{1}{2}(MnO+FeO)}{SiO_2 + \tfrac{1}{2}(Al_2O_3 + TiO_2 + ZrO_2)}$$

The following broad flux categories, listed in order of increasing Basicity Index, can be regarded as covering the bulk of the different varieties of flux used in the submerged arc welding field.

(a) *Acid fluxes: (BI less than ≈0.9).* Characterized by a high content of acidic oxides such as SiO_2 or Al_2O_3, these fluxes are suitable for use with high welding currents and fast travel speeds, and show a high resistance to porosity when welding rusty material.
In general, weld deposits show limited toughness, which is attributed in part to a high weld metal oxygen content. Silicon transfer to the weld metal is high, together with manganese in the case of manganese silicate type fluxes, and a combination of excessive strengthening and limiting toughness precludes the use of these fluxes for multipass welding of thick section materials.

(b) *Neutral fluxes: (BI ≈ 0.9 to 1.2).* These fluxes, generally of the calcium silicate or alumina-rutile type, have lower SiO_2 or Al_2O_3 content which results in them having a neutral chemical character. They show less tendency towards promoting changes in weld chemistry than with the more acidic fluxes, and can be used for multipass welding applications, though weld toughness remains limited due to a relatively high oxygen content. They are suitable for use with fairly high welding currents and travel speeds.

(c) *Semi-basic fluxes: (BI ≈ 1.2 to 1.8).* These are generally calcium silicate or alumina-basic type fluxes where the SiO_2 or Al_2O_3 content has been reduced still further to obtain an optimum balance of weld metal performance and operability characteristics. They are suitable for use with moderately high welding current and travel speed and capable of producing good toughness in two-run as well as multipass welds. These fluxes and the high basicity fluxes which follow are not tolerant to rust on welding surfaces and this should be avoided if the lower oxygen/higher toughness weld characteristics promoted by the flux are to be utilized.

(d) *Basic fluxes: (BI ≈ 1.8 to 2.5).* These fluxes are composed of a higher level of the chemically basic compounds CaO, MgO and CaF_2 and a correspondingly low level of SiO_2. Improved weld metal quality is obtained at the expense of high welding current operability, fast travel speed and slag release performance. They are particularly recommended for multipass welding under thick section material/high restraint conditions, and for the welding of high tensile materials using low alloy steel wires.

(e) *High basicity fluxes: (BI ≈ 2.5 to 3.5).* These fluxes, designed to be used in situations demanding maximum weld toughness performance, are based on a high level of basic compounds and strong deoxidants which aim to minimize weld metal oxygen content. These qualities are obtained with some sacrifices in operability characteristics of the flux, though modern formulations have managed to improve welding current, travel speed and slag release performance to levels above those previously associated with basic fluxes. They are recommended for multipass welding of medium/high tensile C-Mn and low alloy steels, using single or multipass systems.

Not all fluxes can be placed in one class, some falling on the borderline between two classes, so that the welding behaviour and resultant weld chemistry reflect this dual behaviour.

Fluxes may also contain substantial levels of one or more alloying additions, which increase the alloy content of the weld deposit to a degree appreciably higher than that associated with conventional fluxes.

B.6 Wire selection

The selection of wire/flux combinations is usually made to meet the particular requirements of the application.

For low strength C-Mn structural steels where toughness is relatively unimportant, acid and neutral fluxes are often combined with S1 to S4 designation wires, see table 1. Higher toughness can be achieved by using semi-basic and basic fluxes in conjunction with the higher manganese wires, usually those with higher silicon levels, e.g. S2Si and S3 designation wires, see table 1.

For higher strength C-Mn and low alloy structural and pressure vessel quality steels, it is sometimes necessary to use wires alloyed with molybdenum, nickel or combinations of both. Molybdenum is beneficial to impact toughness with high heat input welding, e.g. single or two-run welds using alumina-basic fluxes. Nickel is particularly useful for meeting toughness requirements at sub-zero temperatures and for toughness where post-weld stress-relief is involved, using the higher basicity type fluxes.

Caution should be exercised in selection of wire and flux since it is possible to obtain very poor properties with certain combinations. For example, S1 class wire should not be used with fluxes which do not transfer manganese to the weld metal, i.e. neutral, semi-basic and basic fluxes, otherwise, solidification cracking problems can be experienced*. The manufacturer's advice should always be sought to avoid such possibilities.

* See Welding Institute Booklet 'Solidification cracking of ferritic steels during submerged arc welding', obtainable from the Welding Institute, Abington, Cambs.

Appendix C Parent metal for test plates

The composition of the parent metal used in preparing test pieces and test specimens shall comply with BS 4360, the grades being given in table 9 according to the appropriate subclause of this standard.

The plates shall be in the as-rolled or normalized condition and the chemical composition and tensile strength shall be verified from tests on the plate before the test pieces are prepared.

NOTE. These results should be made available on request.

Table 9. Parent metal for test plates

Subclauses of standard	Parent metal		
	Grade in BS 4360*	Range of tensile strength	
		Over	Up to and including
		N/mm^2	N/mm^2
12.6 and **13.6**	40	400	480
	43	430	510
12.7 and **13.7**	50	500	620
12.8 and **13.8**	55	550	700

*Although steel complying with BS 4360 is used for approval purposes, 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 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.

Appendix D All-weld tests (see clause 12)

D.1 Method of preparing test pieces

The plate material used in preparing test pieces shall be in accordance with appendix C. The temperature of the parent metal used for making test pieces shall be 10 °C to 30 °C immediately before depositing the first run of weld metal. The test pieces shall not be subjected to any mechanical or thermal treatment other than that required by this appendix.

All-weld test pieces shall be prepared in the flat position as shown in figure 1 by depositing weld metal between the chamfered edges of two plates. The plates shall be 20 mm thick. The preparation of the plates shall give an included angle of 20° and the distance between the plates at the root edges shall be approximately 16 mm. The joint shall be closed at the bottom by a backing plate 50 mm wide and at least 12 mm thick. The dimension from square edge to root edge of each side plate shall be at least 200 mm.

The layers of weld metal shall be deposited in single or multiple runs and the direction of deposition of each layer shall be alternately from each end of the assembly. Between 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 mid-way along the run. The assembly shall not be quenched between the deposition of individual runs. The thickness of each layer shall be not less than the diameter of the wire with a minimum thickness of 3 mm. The welding current, voltage and rate of travel shall be in accordance with the recommendations of the manufacturer for the multi-run technique.

When the assembly has been welded it shall be allowed to cool in still air. The portion including the weld shall then be removed by cutting away the excess plate at the place indicated in figure 1.

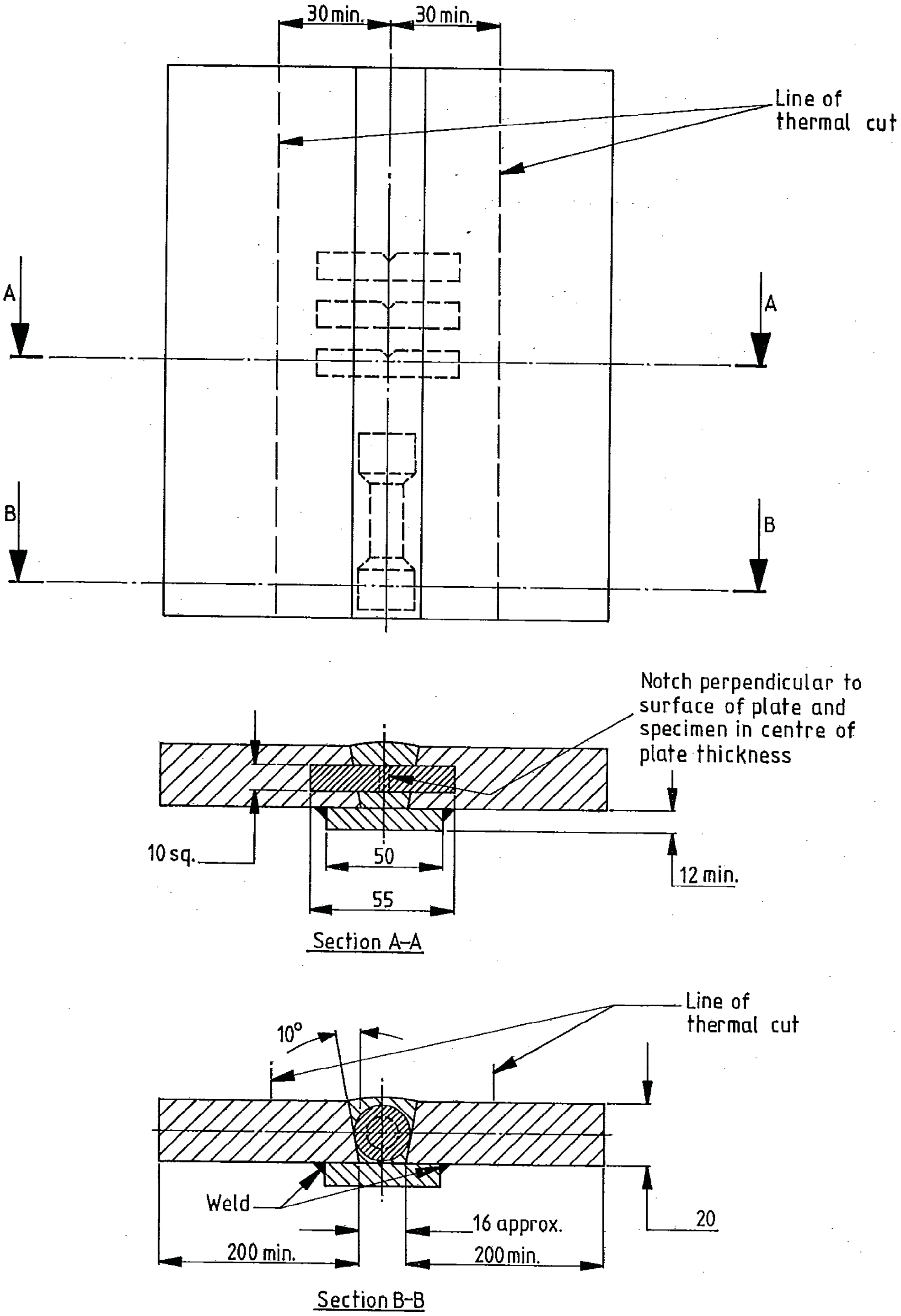
NOTE. These cuts may be made by thermal-cutting, provided care is taken to ensure that the lines of cut for the tensile specimen are at least 30 mm from the centre line of the weld.

D.2 All-weld tensile test

The tensile test specimen shall be machined from the test piece to the dimensions given in figure 2, care being taken that the longitudinal axis of the test specimen coincides with the centre line of the weld and the mid thickness of the plate as indicated in figure 1.

NOTE. The specimen may be subjected to a temperature between 200 °C and 250 °C for a period not exceeding 16 h for hydrogen removal, either before or after machining.

The specimen shall then be tested in tension in accordance with BS 18 : Part 2. Up to the yield point, the stress shall be applied at a rate not exceeding 12 N/mm^2 per second.



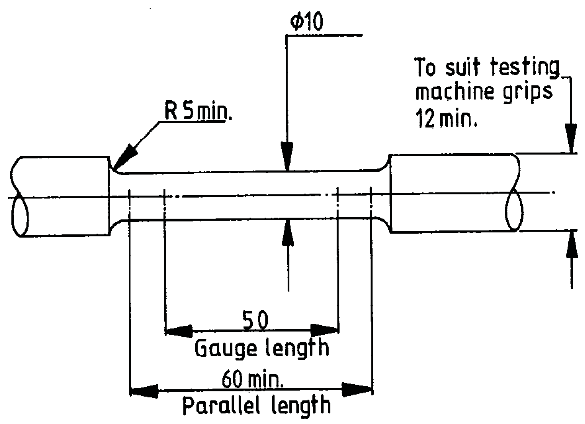
All dimensions are in millimetres.

Figure 1. Method of preparation of all-weld test piece (see clause **12**)

D.3 All-weld impact test

The Charpy V-notch impact test specimens shall be machined from the test piece to the dimensions given in figure 1 of BS 131 : Part 2 : 1972. The test specimens shall be cut with their longitudinal axes transverse to the weld axis and each specimen shall be taken at the mid thickness of the plate. The notch.shall be positioned in the centre of the weld and is to be cut in that face of the test specimen which is perpendicular to the surface of the plate. These test specimens shall not be subjected to any heat treatment.

The specimens shall then be tested in accordance with BS 131 : Part 2.



All dimensions are in millimetres.

Figure 2. All-weld tensile test specimen

Appendix E Transverse tensile and bend tests (see clause 12)

E.1 Method of preparing test pieces

The plate material used in preparing test pieces shall be in accordance with appendix C. The temperature of the parent metal used for making the test pieces shall be 10 °C to 30 °C immediately before depositing the first run of weld metal. The test pieces shall not be subjected to any mechanical or thermal treatment other than that required by this appendix.

Test pieces shall be made as shown in figure 3 by welding together two plates not less than 150 mm wide and of suitable length to allow the cutting out of test specimens of the specified size. The plates shall be 20 mm to 25 mm thick.

The plate edges shall be prepared to form a single-V joint, the details of which shall be as follows, unless they are unsuitable for a particular wire/flux combination, in which case slight alterations to the weld preparation may be made.

Included angle	60°
Root face	5 mm min.
Gap	1 mm max.

NOTE. Plates may be pre-set to allow for slight distortion due to welding.

The welding shall be carried out in the flat position using the welding current, voltage and rate of travel in accordance with the recommendations of the manufacturer for the multi-run technique. A sealing run shall be applied in the flat position after cutting out the root run to clean sound metal.

After welding, each test piece shall be cut, by sawing or machining, to form one transverse tensile, one face bend and one root bend test specimen as indicated in figure 3.

E.2 Transverse tensile test

Transverse tensile test specimens shall conform to the dimensions given in figure 4. The upper and lower surfaces of the weld shall be filed, ground or machined level with the respective original surfaces of the plates.

NOTE. 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.

The test specimens shall then be tested in tension in accordance with BS 18 : Part 2.

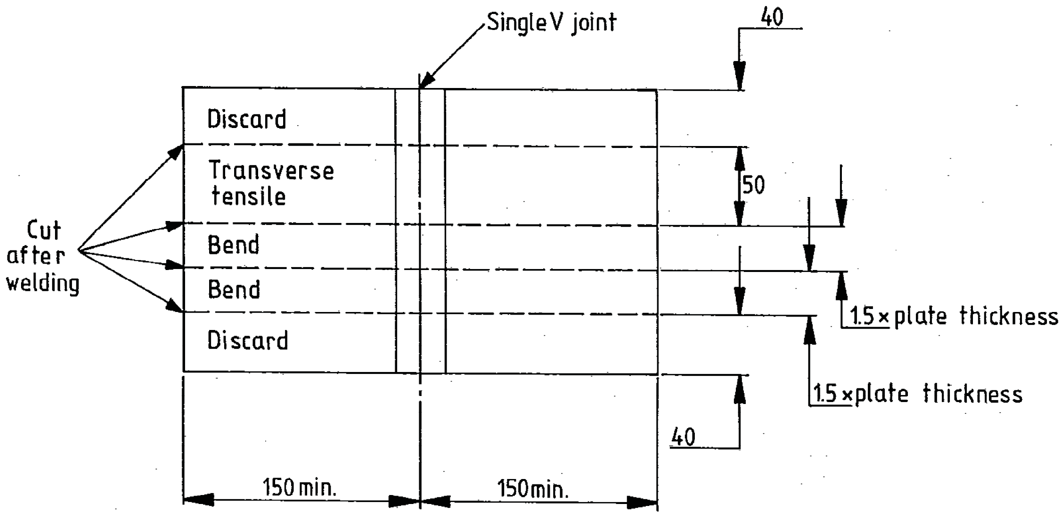
E.3 Transverse bend test

The width of each bend test specimen shall be 1.5 times plate thickness. The upper and lower surfaces of the weld shall be filed, ground or machined level with the respective original surface of the plates, with the proviso as given in the note in **E.2**.

NOTE. Tool marks should be avoided as they lead to localization of stress and may cause premature failure. For this reason the direction of machining of the surfaces should be along the specimens and transverse to the weld.

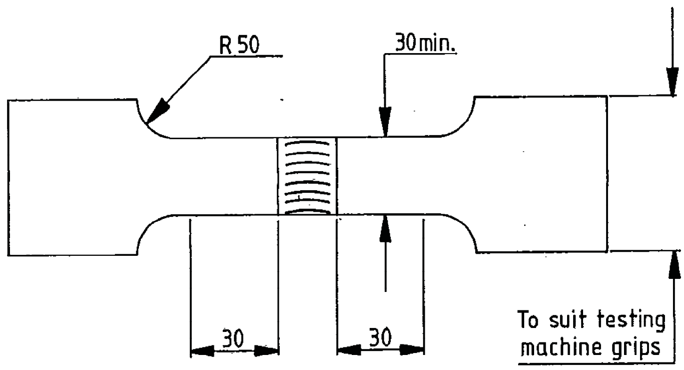
The sharp corners of test specimens shall be rounded to a radius not exceeding 10 % of the specimen thickness.

The test specimens shall be bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimen for M300 grade and four times the thickness of the specimen for M350 and M450 grades, as shown in figure 5. One specimen of each pair shall be tested with the face of the weld in tension and the other with the root of the weld in tension.



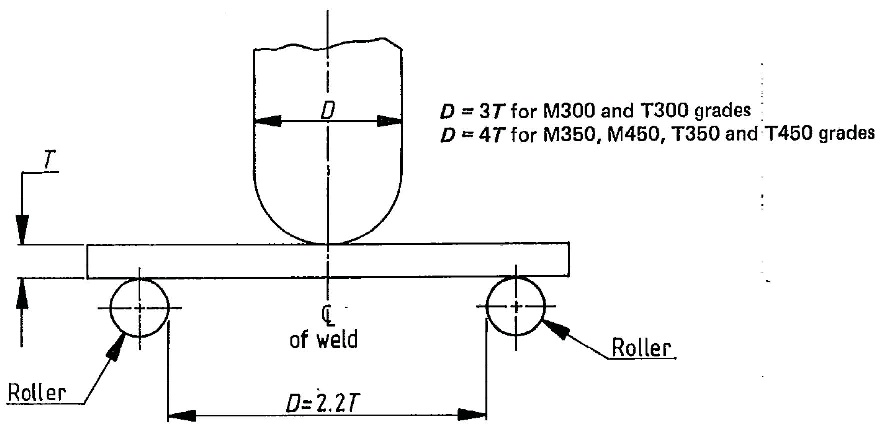
All dimensions are in millimetres.

Figure 3. Test piece for transverse tensile and bend test specimens (see clause **12**)



All dimensions are in millimetres.

Figure 4. Transverse tensile test specimen



All dimensions are in millimetres.

Figure 5. Method of testing transverse bend specimens

Appendix F Butt weld tests (see clause 13)

F.1 Method of preparing test pieces

The plate material used in preparing test pieces shall be in accordance with appendix C. The temperature of the parent metal used for making the test pieces shall be 10 °C to 30 °C immediately before depositing the first run of weld metal. The test pieces shall not be subjected to any mechanical or thermal treatment other than that required by this appendix.

Test pieces shall be made as shown in figure 6 by welding together two plates, not less than 150 mm wide and of sufficient length to allow the cutting out of test specimens of the specified size. The plate thickness and weld preparation shall be in accordance with the details given in table 10, unless the details of table 10 are unsuitable for a particular wire/flux combination, in which case slight alterations may be made to suit but back-grooving shall not be carried out.

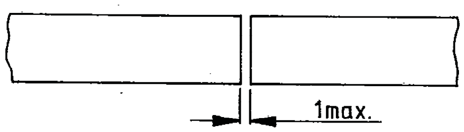
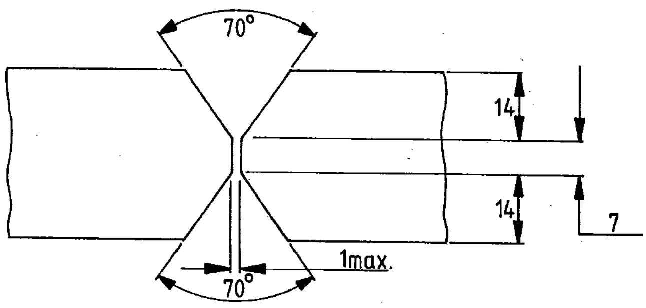
The test pieces shall be welded in the flat position using the welding current, voltage and rate of travel in accordance with the recommendations of the manufacturer for the two-run technique.

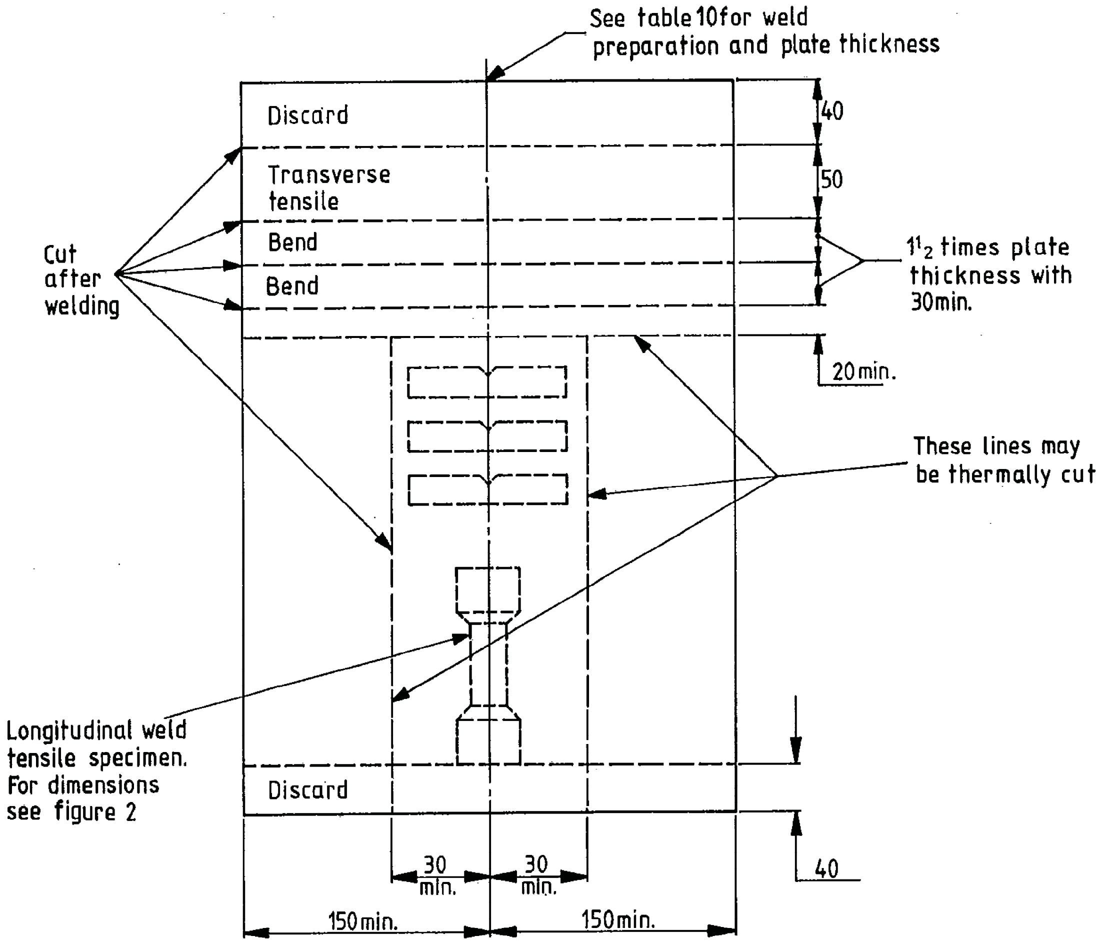
After completion of the first run, the flux and welding slag shall be removed and each assembly shall be left in still air until it has cooled to 100 °C, the temperature being taken on the weld surface mid-way along the run.

Each test piece shall be so marked that the side first welded remains identifiable after the test specimens have been cut out.

After welding, test specimens shall be cut, by sawing or machining, to provide one longitudinal weld tensile specimen, three impact specimens, one transverse tensile specimen and two transverse bend specimens, as indicated in figure 6.

Table 10. Weld details for preparation of butt weld test pieces

Plate thickness	**Weld preparation** (All dimensions are in millimetres)	**Wire size submitted for approval**
mm 12 to 16	 	mm 3.2 or less
35	 	Largest



All dimensions are in millimetres.

Figure 6. Test piece for butt weld tests (see clause 13)

F.2 Longitudinal weld tensile test

The tensile test specimen shall be machined from the test piece to the dimensions given in figure 2. If necessary, additional weld metal shall be deposited at the ends of the test piece so that the size of the ends of the specimen will suit the testing machine grips. The specimen shall be taken at the location indicated in figure 7, care being taken that the longitudinal axis of the test specimen coincides with the centre line of the weld.

NOTE. The specimen may be subjected to a temperature between 200 °C and 250 °C for a period not exceeding 16 h for hydrogen removal, either before or after machining.

The specimen shall then be tested in tension in accordance with BS 18 : Part 2. Up to the yield point, the stress shall be applied at a rate not exceeding 12 N/mm^2 per second.

F.3 Impact test

The Charpy V-notch impact test specimens shall be machined from the test piece to the dimensions given in figure 1 of BS 131 : Part 2 : 1972. The test specimens shall be cut with their longitudinal axes transverse to the weld axis and shall be taken at the location indicated in figure 7. The notch shall be positioned in the centre of the weld and is to be cut in that face of the test specimen which is perpendicular to the surface of the plate.

The specimens shall then be tested in accordance with BS 131 : Part 2.

F.4 Transverse tensile test

The transverse tensile test specimen shall conform to the dimensions given in figure 4. The upper and lower surfaces of the weld shall be filed, ground or machined level with the respective original surfaces of the plates.

NOTE. Where the surfaces of the plates are not level with each other, the metal may be cut away to bring them approximately level, provided the thickness of the plate is not reduced by more than a total of 1 mm.

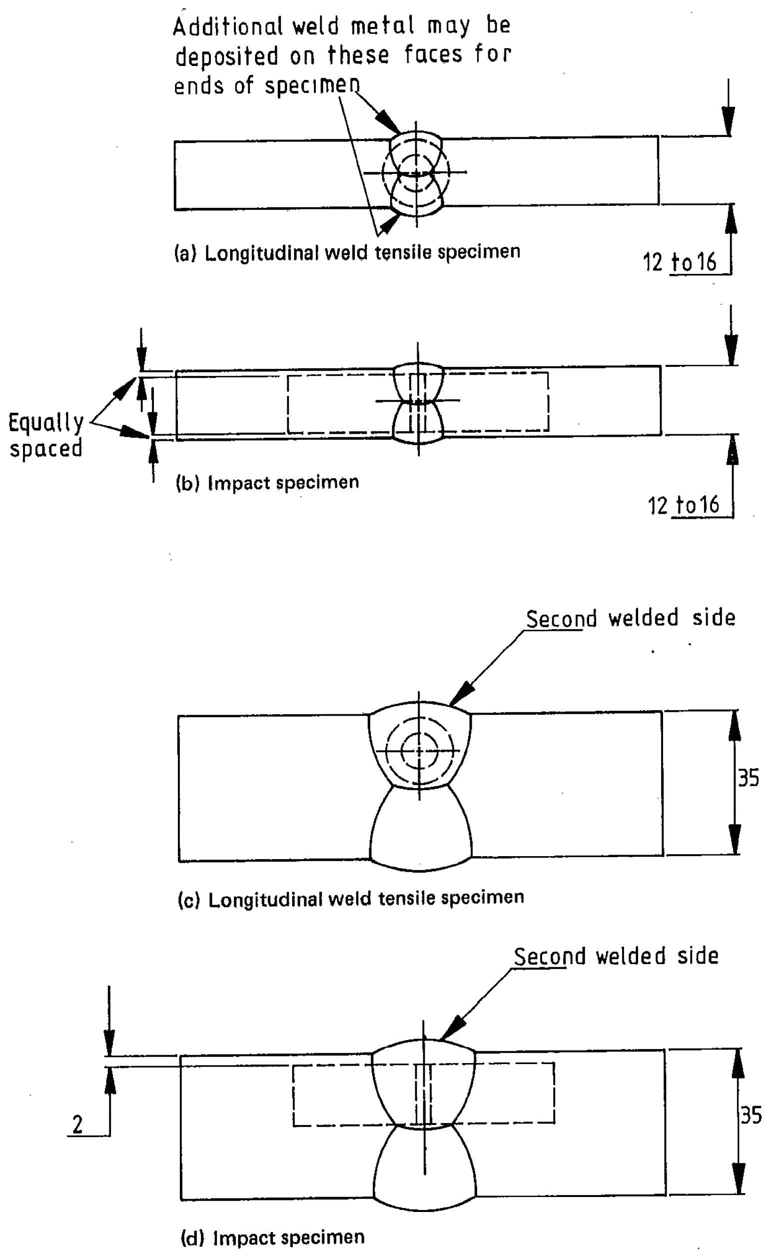
The specimen shall then be tested in tension in accordance with BS 18 : Part 2.

F.5 Transverse bend test

The width of each bend test specimen shall be 1½ times the specimen thickness with a minimum of 30 mm. The upper and lower surfaces of the weld shall be filed, ground or machined level with the respective original surfaces of the plates, with the proviso as given in the note in F.4. The sharp corners of the specimen shall be rounded to a radius not exceeding 10 % of the specimen thickness.

NOTE. Tool marks should be avoided as they lead to localization of stress and may cause premature failure. For this reason, the direction of machining of the surfaces should be along the specimen and transverse to the weld.

The test specimens shall be bent through an angle of 120° over a former having a diameter equal to three times the thickness of the specimen for T300 grade and four times the thickness of the specimen for T350 and T450 grades, as shown in figure 5. One test specimen shall be tested with the first welded side in tension and one with the other side in tension.



All dimensions are in millimetres.

Figure 7. Location of longitudinal weld tensile and impact specimens for various thicknesses of test piece (see clause 13)

Appendix G Health and safety publications

The following publications about health and safety are available.

The Facts About Fume. The Welding Institute, Abington 1976.

Welding Fume. The Welding Institute, Abington 1981.

Health and Safety Executive Guidance Note EH15 'Threshold Limit Values'.

Department of Employment Guidance Note MS15 'Welding'.

American Standard ANSI Z 49.1 'Safety in Cutting and Welding'. American Welding Society 1973.

Health Hazards of Welding, Dr H T Doig, British Safety Council.

Welding Manufacturer's Association, Publication No. 237 'The Arc Welder at Work'.

BS 679 Filters for use during welding and similar industrial operations.

Publications referred to

BS 18	Methods for tensile testing of metals Part 2 Steel (general)
BS 131	Methods for notched bar tests Part 2 The Charpy V-notch impact test on metals
BS 499	Welding terms and symbols Part 1 Welding, brazing and thermal cutting glossary
BS 679	Filters for use during welding and similar industrial operations
BS 4360	Specification for weldable structural steels
BS 4870*	Approval testing of welding procedures Part 1 Fusion welding of steel
BS 4891	A guide to quality assurance

BS Handbook No. 19 Methods for the sampling and analysis of iron, steel and other ferrous metals

* Referred to in the foreword only.

For information about BSI services relating to third party certification to suitable British Standard product specifications, sc for the registration of firms of assessed capability, testing and inspection facilities, please contact the Director, Quality Ass Division, BSI, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ. Tel. Hemel Hempstead 3111.

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The following BSI references relate to the work on this standard: Committee reference WEE/39 Draft for comment 83/73407 DC

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Welding Standards Committee (WEE/-) to Technical Committee WEE/39 upon which the following bodies were represented:

Associated Offices Technical Committee
British Association for Brazing and Soldering
British Railways Board
British Shipbuilders
British Steel Industry
British Steel Industry (Wire Section)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Process Plant Association
Society of Motor Manufacturers and Traders Limited
Welding Institute
Water-tube Boilermakers' Association
Welding Manufacturers' Association (BEAMA Ltd.)
Coopted member

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Constructional Steelwork Association
Ministry of Defence
United Kingdom Atomic Energy Authority

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