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METHODS FOR

MECHANICAL TESTING OF STEEL WIRE

BRITISH STANDARDS INSTITUTION

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THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the Executive Board on 30th January, 1970.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 427. Method for Vickers hardness test. Part 1. Testing of metals.
BS 1610. Methods for the load verification of testing machines.
BS 3688. Methods for mechanical testing of metals at elevated temperatures.
Part 1. Tensile testing.
BS 3846. Methods for calibration and grading of extensometers for testing of metals.

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The following BSI references relate to the work on this standard:
Committee reference MEE/37 Draft for comment 68/21847

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The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Associated Offices' Technical Committee
Association of Consulting Engineers
Association of Mining Electrical and Mechanical Engineers
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The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Aluminium Federation
British Cast Iron Research Association
British Non-Ferrous Metals Research Association
Geochemical Laboratories
Institution of Engineering Inspection
Welding Institute

BRITISH STANDARD METHODS FOR

MECHANICAL TESTING OF STEEL WIRE

FOREWORD

This British Standard has been prepared under the authority of the Mechanical Engineering Industry Standards Committee in the interests of bringing together the various methods for the mechanical testing of steel wire which have previously appeared in each individual standard for the particular product.

The standard is divided into 4 sections respectively dealing with tensile, torsion, reverse bending and wrapping tests, these sections being based on the corresponding ISO Recommendation* covering the mechanical testing of steel wire. The Recommendations concerned with tensile, torsion and reverse bending tests are at present in course of revision, and due account has been taken of the latest international agreements in the corresponding sections of this standard.

Attention is drawn to the fact that, with the publication of this standard, reference should no longer be made to BS 18† in so far as the tensile testing of steel wire is concerned.

NOTE. Information concerning SI units is given in BS 350, 'Conversion factors and tables' and PD 5686, 'The use of SI units'.

METHODS OF TEST

0. SCOPE

This British Standard describes procedures for the mechanical testing of steel wire, and covers, in Section 1, tensile testing, Section 2, torsion testing, Section 3, reverse bend test and in Section 4, a wrapping test. The first clause (General) in each section deals more specifically with the range and type of wire to which the procedures apply.

1. TENSILE TEST

1.1 GENERAL

1.1.1 This section applies to wire products which have usually been cold-worked and are of constant cross section, either round, square, rectangular or special.

* ISO/R 89, 'Tensile testing of steel wire'.
ISO/R 136, 'Simple torsion test of steel wire'.
ISO/R 144, 'Reverse bend testing of steel wire'.
ISO/R 145, 'Wrapping test for steel wire'.

† BS 18, 'Methods for tensile testing of metals'.

The dimensions of the cross section are always very small compared with the usual lengths produced, and for wire of rectangular or special cross section the ratio of width to thickness is generally less than 4. The diameter, or other characteristic dimension, is usually not greater than 10 mm.

1.1.2 The test shall be carried out with the temperature of the test piece between 10 °C and 30 °C. For tests at elevated temperatures, reference should be made to BS 3688, Part 1*.

1.2 PRINCIPLE OF TEST

The test consists of straining a test piece by tensile stress, generally to fracture, with a view to determining one or more of the mechanical properties described in this section.

1.3 DEFINITIONS AND SYMBOLS

1.3.1 For the purposes of this section, the following definitions and symbols apply:

(1) *Gauge length.* The prescribed part of the cylindrical or prismatic portion of the test piece on which elongation is measured at any moment during the test.

(2) *Original gauge length* (L_o). The gauge length before the test piece is strained.

(3) *Final gauge length* (L_u). The gauge length after the test piece has been fractured and the fractured parts have been carefully fitted together so that they lie in a straight line.

(4) *Extensometer gauge length* (L_e). The length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer. The length may differ from L_o.

(5) *Percentage permanent elongation.* The variation of the gauge length of a test piece subjected to a prescribed stress (see definition (13)) and, after removal of the same, expressed as a percentage of the original gauge length. If a symbol for this elongation is used it should be supplemented by an index indicating the prescribed stress.

(6) *Percentage elongation after fracture* (A). The permanent elongation of the gauge length after fracture $L_u - L_o$, expressed as a percentage of the original gauge length L_o.

NOTE. The symbol, A, should be supplemented by a suffix denoting the gauge length.

* BS 3688, 'Methods for mechanical testing of metals of elevated temperatures', Part 1, 'Tensile testing'.

(7) *Percentage reduction of area* (Z). The ratio of the maximum change in cross-sectional area, which has occurred during the test $S_o - S_u$, to the original cross-sectional area S_o, expressed as a percentage. (S_u = minimum cross-sectional area after fracture.)

(8) *Maximum load* (F_m). The highest load which the test piece withstands during the test.

(9) *Stress* (*actually 'nominal stress'*). At any moment during the test, load divided by the original cross-sectional area of the test piece.

(10) *Tensile strength* (R_m). The maximum load divided by the original cross-sectional area of the test piece, i.e. stress corresponding to the maximum load.

(11) *Proof stress* (*non-proportional elongation*) (R_p). The stress at which a non-proportional elongation, equal to a specified percentage of the original gauge length, occurs.

NOTE. When a proof stress (R_p) is specified, the non-proportional elongation should be stated (e.g. 0·2 %) and the symbol used for the stress should be supplemented by an index giving this prescribed percentage of the original gauge length, e.g. $R_{p0.2}$.

(12) *Proof stress* (*total elongation*) *or proof stress under load* (R_t). The stress at which a non-proportional elongation plus elastic elongation, equal to a specified percentage of the original gauge length, occurs.

NOTE 1. When a proof stress (R_t) is specified, or agreed between the interested parties, the total elongation should be stated and the symbol used for the stress should be supplemented by an appropriate index, e.g. $R_{t0.5}$.
NOTE 2. The value obtained by this total elongation method will only be equivalent to R_p if suitable allowance is made for the measurement of elastic extension.

(13) *Permanent set stress* (R_r). The stress at which, after removal of load, a prescribed permanent elongation, expressed as a percentage of the original gauge length, occurs. The symbol used for this stress is supplemented by an index giving the prescribed percentage of the original gauge length, e.g. $R_{r0.2}$.

(14) *Yield stress* (*apparent*) (R_e). The value of stress determined from the load at which a hesitation or drop of load applied by the testing machine is first observed. The load taken is usually that recorded by the maximum reading device or slave pointer of the testing machine during yield extension.

1.3.2 Additional symbols. Additional symbols used in tensile testing are as follows:

d = diameter of round wire or other characteristic dimension;
a = thickness of a flat wire;
b = width of a flat wire.

NOTE. In correspondence and where no misunderstanding is possible, the symbols L_o and R_m may be replaced by L and R respectively

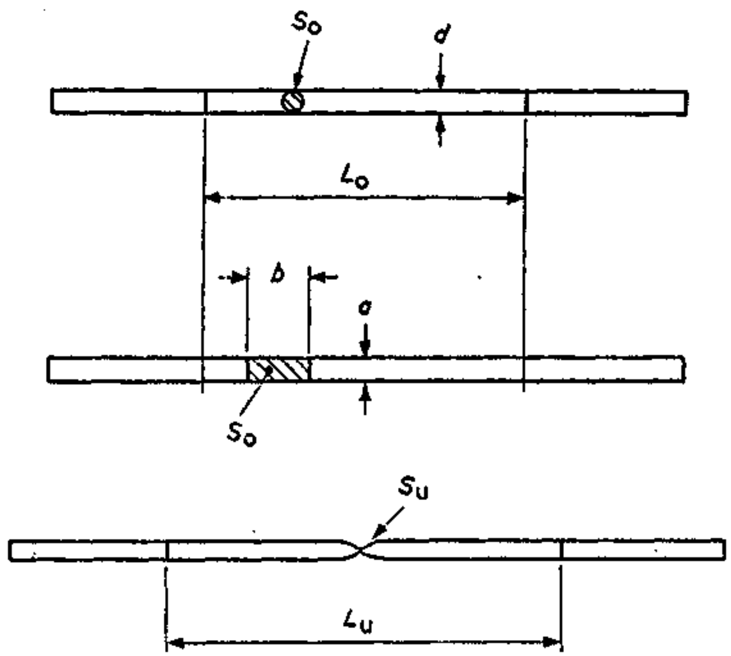

Fig. 1. Diagrammatic sketches of wire test pieces

1.4 TEST PIECES

1.4.1 The cross section of the test piece shall be that of the wire.

1.4.2 As proportional test pieces are not generally appropriate for tests on wire, the usual gauge length is 100 mm or 200 mm and preference shall be given to the latter. For diameters of 3 mm and greater, the minimum practical gauge length is usually 10*d*. As an interim measure, gauge lengths of 50 mm and 250 mm are permitted.

1.4.3 The distance between grips shall be at least 50 mm greater than the gauge length.

1.5 PREPARATION OF TEST PIECES

If straightening is necessary, this shall be done by hand if practicable, but otherwise a hammer having a head of wood, plastics or other suitable material shall be used, the wire being supported on a flat surface of wood or other suitable material so as to minimize damage to the surface of the wire.

1.6 CROSS-SECTIONAL AREA

1.6.1 The cross-sectional area shall be calculated from measurements of the appropriate dimensions with an error on each dimension of not more than $\pm 0{\cdot}5\%$ for wire of 3 mm and larger, and $\pm 1{\cdot}0\%$ for wire of less than 3 mm.

1.6.2 For wires having dimensions complying with the tolerances of a material specification, the nominal dimensions may be used in calculations, unless otherwise specified in the standard for the material.

1.6.3 For wire of special shape, the cross-sectional area may be determined from the mass of a known length and its density.

1.7 MARKING THE ORIGINAL GAUGE LENGTH

1.7.1 When the elongation is to be determined, the length of the test piece between grips shall be marked at intervals equal to half the gauge length, except for a distance of at least 2*d* from each grip. The gauge length shall be marked to an accuracy of $\pm 0{\cdot}5$ mm.

1.7.2 The test piece shall be straight before it is marked with either fine ink or superficial scribed lines. The latter may be made more easily visible by first painting the wire with a quick drying ink or dye.

1.8 METHOD OF GRIPPING

1.8.1 Test pieces shall be held by wedge grips having serrations which will produce the minimum depth of notch in the wire commensurate with effective grip. Soft metal inserts coated with carborundum may be used with very sensitive materials or small wires. Capstans or similar means are preferable for holding the smallest diameter wires.

1.8.2 Every endeavour shall be made to ensure that test pieces are held in such a way that the load is applied as axially as possible. This is of particular importance when determining proof stress or yield stress.

1.9 ACCURACY OF TESTING EQUIPMENT

1.9.1 Testing machine. The testing machine shall be verified in accordance with BS 1610* and shall be maintained to Grade A except when Grade B is permitted by the standard for the material.

1.9.2 Extensometer. The instrument error of an extensometer including ancillary electronic or autographic equipment shall not exceed 5 % of the value of the elongation of which the stress value is obtained. Extensometers shall be calibrated in accordance with BS 3846*.

* BS 1610, 'Methods for the load verification of testing machines'.

1.10 DETERMINATION OF PROPERTIES

The appropriate properties to be determined shall be stated in the standard for the material and shall be determined in accordance with the procedures described in 1.11 to 1.16.

1.11 DETERMINATION OF PROOF STRESSES

1.11.1 *General.* For the determination of proof stress (non-proportional elongation), R_p, or proof stress (total elongation), R_t, the rate of application of stress shall not exceed 30 MN/m²/s† and may be within the range 3 MN/m²/s to 30 MN/m²/s. Under no circumstances shall the actual strain rate of the test piece at the time the proof stress is determined exceed 0·01/s (0·6/min). For both procedures an extensometer shall be used. The required percentage strain or total elongation at which a proof strain is to be determined shall be stated in the standard for the material or agreed between the interested parties.

1.11.2 *Proof stress (non-proportional elongation)* (R_p). The proof stress (non-proportional elongation) (R_p) is determined from a load/extension (stress-strain) diagram on which a line is drawn parallel to the straight portion of the curve and distant from it by an amount representing an increase of extension equal to the required non-proportional amount, e.g. 0·2 %. The point at which the line cuts the curve represents the required proof load (stress). Accurate determination of the load/extension diagram is necessary, see 1.9.2. The curve may be obtained by either automatic or manual methods. The use of an electronic proof stress indicator without the production of an actual load/extension diagram is however permitted.

1.11.3 *Proof stress (total elongation)* (R_t)

1.11.3.1 The proof stress (total elongation) (R_t) is determined from a load/extension diagram on which a line is drawn parallel to the *y* axis of the diagram and distant from it by an amount representing an increase of extension equal to the required total elongation. The curve may be obtained by either automatic or manual methods.

1.11.3.2 Alternatively a direct determination may be obtained by observation of the load at which the total elongation, as measured by the extensometer,

* BS 3846, 'Methods for calibration and grading of extensometers for testing of metals'.
† 10 MN/m² = 1 hbar ≃ 1 kgf/mm² ≃ 0·65 tonf/in².

is equal to the specified total elongation. To allow for elastic extension at the initial load applied to the test piece before attachment of the extensometer, the dial of the latter shall be adjusted to read a strain calculated from the initial load and nominal modulus of elasticity stated in the standard for the material.

1.12 PROVING TESTS FOR PERMANENT SET STRESS

1.12.1 If a permanent set stress is specified or agreed, the small tensioning stress stated in the specification for the material shall be applied to the test piece. The stress is increased to the specified permanent set value and maintained for 10 s to 15 s. It is then reduced below the initial tensioning stress and is then increased again to the tensioning value.

1.12.2 It shall be verified that the gauge length, when measured with an extensometer, has not acquired a permanent extension greater than the specified percentage of the extensometer gauge length. The permanent extension is the difference of the extensometer readings between the initial and final application of the small tensioning stress.

1.13 DETERMINATION OF YIELD STRESS

For wire which exhibits a yield phenomenon, the determination of yield stress, R_e, is made in accordance with the definition given in 1.3.1(14). The rate of loading in the elastic range shall not exceed 30 $MN/m^2/s$.

1.14 DETERMINATION OF TENSILE STRENGTH

1.14.1 If values of proof stress are to be determined during the test, the rate of application of stress shall comply with the requirements given in 1.11.1 until the required proof stress has been determined. Thereafter the rate may be increased, but the maximum rate of application of stress after the proof stresses have been determined shall not exceed 100 $MN/m^2/s$.

1.14.2 When the tensile strength *only* is to be determined, the maximum rate of application of stress throughout the test shall not exceed 100 $MN/m^2/s$.

1.14.3 If failure of the test piece occurs at or within the grips, the test piece may be discarded and a further test carried out.

1.15 DETERMINATION OF PERCENTAGE ELONGATION AFTER FRACTURE

1.15.1 The percentage elongation after fracture is determined in accordance with the definition given in 1.3.1(6). The final gauge length shall be measured to an accuracy of $\pm 0{\cdot}5$ mm.

1.15.2 Any statement of the results of a percentage elongation test shall include the gauge length.

1.15.3 The full value of the percentage elongation may not be obtained unless fracture of the test piece has occurred at a section situated between the gauge marks, and at a sufficient distance from the nearest gauge mark. Care shall be taken to ensure proper contact between the broken parts of the test pieces when measuring the final length between gauge marks. This is of particular importance when measuring test pieces of small cross section and test pieces having low elongation values. The wire pieces shall be supported across a straightedge and may be conveniently held in position by plasticene while measurement of the increase in gauge length is made between the two marks on either side of the mark nearest to the fracture. For wires having low elongation values, measurement should be made with a vernier gauge.

1.15.4 In acceptance testing the results are regarded as valid, irrespective of the position of fracture, provided that the minimum elongation specified has been obtained. If the position of fracture is less than 2*d* from a last gauge mark adjacent to a grip, and the minimum specified elongation is not obtained, the test piece shall be discarded and a further test made.

1.16 DETERMINATION OF PERCENTAGE REDUCTION OF AREA

1.16.1 Unless otherwise specified, the percentage reduction of area is only determined on wires having a diameter of 3 mm and greater.

1.16.2 The percentage reduction of area shall be determined in accordance with the definition given in 1.3.1(7).

2. TORSION TEST

2.1 GENERAL

2.1.1 The section applies to the simple torsion testing of steel wire having a nominal size generally of 0·4 mm and larger.

2.1.2 Unless otherwise specified, the test shall be carried out at ambient temperature.

2.2 PRINCIPLE OF TEST

The test consists of twisting a test piece round its own axis until the test piece breaks or until the specified number of twists have been made. The twisting shall be in the same direction during the test.

2.3 SYMBOLS AND DESIGNATIONS

For the purposes of this section, the following symbols and designations apply:

Symbol	*Designation*
d	Nominal diameter of round wire or characteristic dimension for non-circular wires. NOTE. The characteristic dimension for non-circular wires is usually given in the standard for the material.
L	Free length between grips.
N_t	Number of turns.

2.4 TESTING MACHINE

2.4.1 The grips of the testing machine shall be arranged in such a way that, during testing, they remain on the same axis and do not apply any bending to the test piece.

2.4.2 The machine shall be so constructed that the change of length between the grips during the test is not prevented.

2.4.3 One of the grips shall be capable of being rotated around the axis of the test piece while the other should not be subject to any angular deflection, except for such deflection as may be necessary to measure the torque.

2.4.4 The distance between the grips shall be capable of adjustment for different test lengths.

2.4.5 The machine shall be constructed so that a suitable tensile stress may be applied to the test piece.

2.5 TEST PIECE

2.5.1 The test piece, consisting of a piece of wire, shall be straight before being tested. If straightening is necessary it should be done by hand or, if this is not possible, straightening should be by hammering on a level surface of wood, plastics material or copper using a hammer made of one of these materials so as to minimize damage to the surface of the wire.

2.5.2 The free length between the grips of the machine shall be as given in Table 1.

TABLE 1. FREE LENGTH BETWEEN GRIPS

Nominal size d		Free length between grips L
Equal to and over	Under	
mm	mm	
0·4	1	200d
1	3·6	100d
3·6	5	100d
5		50d

2.5.3 For very small sizes of wire, the length between grips may be increased to 400d, and for wires larger than 5 mm the length between grips may, if convenient, be 100d.

NOTE. Shorter lengths may be used by special agreement. If the specified length in Table 1 is 100d or 50d, the alternative shorter length should be 50d or 30d respectively.

2.6 PROCEDURE

2.6.1 The test piece is placed in the machine in such a way that its longitudinal axis coincides with axis of the grips and so that it remains straight during the test. Unless otherwise specified, this may be ensured by applying to the test piece a constant tensile stress just sufficient to straighten it, but not exceeding 2% of the nominal tensile strength of the wire.

2.6.2 After placing the test piece in the machine, one grip is rotated at a reasonably constant speed until the test piece breaks or until the specified number of turns is reached. The number of complete turns of the rotating grip should be counted.

TABLE 2. SPEED OF TESTING

Nominal size d		Maximum number of turns/minute per 100d	Equivalent turns per minute in preferred length given in Table 1
Equal to and over	Under		
mm	mm		
0·4	1·0	90	180
1·0	3·6	60	60
3·6	5·0	30	30
5·0		30	15

2.6.3 The speed of testing shall be sufficiently slow to prevent any rise in temperature likely to affect the result of the test, and preferably shall not exceed the values given in Table 2.

2.7 TEST REQUIREMENTS

2.7.1 If the number of turns is satisfactory, the test piece is considered as having passed the test, irrespective of the position of failure. If the number of turns reached does not satisfy the requirements of the specification, and if the failure is within $2d$ of the grips, the test shall be considered as invalid and shall be repeated.

2.7.2 If so required by the specification for the material, the surface of the test piece including the fracture shall be examined. The method of examination and the interpretation of the appearance of the test piece should be stated in the material specification.

3. REVERSE BEND TEST

3.1 GENERAL

3.1.1 This section applies to the reverse bend testing of wire having a diameter or major dimension equal to or greater than 0·4 mm.

3.1.2 Unless otherwise specified, the test shall be carried out at ambient temperature.

3.2 PRINCIPLE OF TEST

The test consists of repeated bending of a test piece through 90° in opposite directions, in one plane. The test piece is gripped at one end and each bend is made over a cylindrical surface of specified radius.

3.3 SYMBOLS AND DESIGNATIONS

For the purposes of this section, the following symbols and designations apply, see also Figs. 2 and 4:

Symbol	Designation
d	Diameter of a round wire.
a	Minimum thickness of a wire of non-circular section which it is possible to arrange between parallel grips.
R	Radius of curvature of cylindrical former.
h	Distance from top of cylindrical former to bottom face of guide.

Symbol	Designation
d_g	Diameter of guide hole.
y	Distance from centre of curvature of the cylindrical former to the top edge of the gripping faces.
N_b	Number of reverse bends.

3.4 TEST PIECE

3.4.1 The length of wire to be used as the test piece shall be as straight as possible, but it may exhibit slight curvature in the plane in which it will be bent during the test.

3.4.2 If straightening is necessary it shall be done by hand. If this is not possible, straightening should be by hammering on a level surface of wood, plastics material or copper using a hammer made of one of these materials so as to minimize damage to the surface of the wire.

3.5 TESTING MACHINE

3.5.1 The testing machine shall be constructed to conform to the principles indicated in Fig. 2 and the essential dimensions given in Table 3.

3.5.2 Cylindrical formers and gripping faces

3.5.2.1 The cylindrical formers and the gripping faces of the blocks shall be made of material having good wear resistance with a hardness of preferably not less than 750 HV*. The design of machine shall allow for the renewal of cylindrical formers and gripping faces.

3.5.2.2 The radius of the cylindrical formers shall not differ from the nominal dimension by more than the tolerance given in Table 3 and, in any case, the radius of the formers shall not differ from each other by more than 0·05 mm.

3.5.2.3 The axes of the formers shall be parallel. With the test piece vertical, the horizontal planes containing the formers shall not be displaced by more than 0·1 mm.

3.5.2.4 The gripping faces shall project slightly beyond the surface of the cylindrical formers to a distance which does not exceed 0·1 mm, as measured by the clearance between the test piece and each cylindrical former on a line joining their centres of curvature.

3.5.2.5 The top edge of the gripping faces shall be below the line joining the centres of curvature of the cylindrical formers by a distance of 1·5 mm for formers of radius equal to or less than 2·5 mm, and 3 mm for formers of a larger radius.

* BS 427, 'Method for Vickers hardness test', Part 1, 'Testing of metals'.

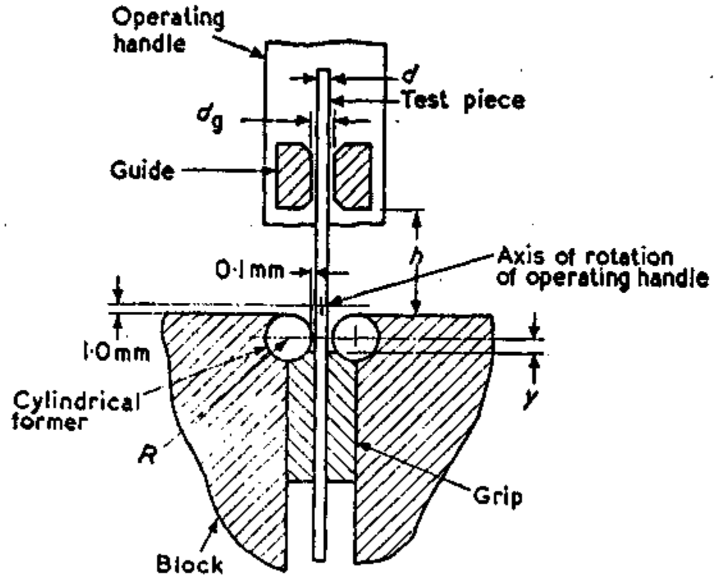

Fig. 2. Essential elements of bend testing machine for wire

TABLE 3. DIMENSIONS OF ELEMENTS OF TESTING MACHINE

Nominal diameter of wire d	Radius of cylindrical former R	Distance h	Diameter of hole in carrier (see Note 1) d_g
mm	mm	mm	mm
0·4 to 0·5	1·25 ± 0·05	15	2·0
Over 0·5 to 0·7	1·75 ± 0·05	15	2·0
Over 0·7 to 1·0	2·5 ± 0·1	15	2·0
Over 1·0 to 1·5	3·75 ± 0·1	20	2·0
Over 1·5 to 2·0	5 ± 0·1	20	2·0 and 2·5
Over 2·0 to 3·0	7·5 ± 0·1	25	2·5 and 3·5
Over 3·0 to 4·0	10 ± 0·1	35	3·5 and 4·5
Over 4·0 to 6·0	15 ± 0·1	50	4·5 and 7·0
Over 6·0 to 8·0	20 ± 0·1	75	7·0 and 9·0
Over 8·0 to 10·0	25 ± 0·1	100	9·0 and 11·0

NOTE 1. Where appropriate, the smaller diameter of hole should be used for the smaller nominal diameter of wire (see Column 1) and the larger diameter of hole for the larger nominal diameter of wire (see also Column 1). For diameters within the ranges given in Column 1, the appropriate size of hole should be chosen to ensure free movement of the wire.

NOTE 2. It is recognized that some existing testing machines may not conform to the requirements of Table 3 over the whole range. It is, however, essential that such machines conform to the following:

Distance h: 20 mm to 25 mm for wire diameters up to and including 2·5 mm. 50 mm for wire diameters over 2·5 mm up to and including 5 mm.

Diameter of hole d_g: Not greater than 1·5d wherever practicable.

3.5.3 Bending arm and guide arm

3.5.3.1 The distance of the pivoting axis of the bending arm from the top of the cylindrical formers shall be 1·0 mm for all sizes of former.

3.5.3.2 The angular movement of the bending arm shall be limited by stops so that the centre line of the arm will describe a 90° arc.

3.5.3.3 The distance from the top of the cylindrical former to the underside of the guide arm shall be in accordance with Table 3.

3.5.3.4 The holes in the guide arm shall widen out at each end and have a diameter in accordance with Table 3.

3.5.3.5 To ensure correct alignment of test and contact with the cylindrical former, when testing small sizes of wire over formers of radius equal to or less than 2·5 mm, the guide arm shall be fitted with a tensioning device, capable of applying a load to the wire of preferably not less than 1 % and not more than 3 % of the nominal or specified breaking load of the wire.

3.6 TEST PROCEDURE

3.6.1 The radius of former (R), distance (h) and diameter of hole (d_g) shall be selected according to wire diameter as given in Table 3. For wires of special shape reference should be made to the material specification.

3.6.2 With the bending arm in the vertical position, the test piece shall be threaded through one of the holes in the guide arm. One end of the wire shall then be held vertically between the gripping faces of the blocks.

3.6.3 Non-circular test pieces shall be placed so that the greater dimension is parallel or approximately parallel to the gripping faces, as shown in Fig. 3.

3.6.4 The end of the wire in the guide arm shall be bent over one cylindrical former through 90° and then back to the vertical position. This counts as one reverse bend (see Fig. 4).

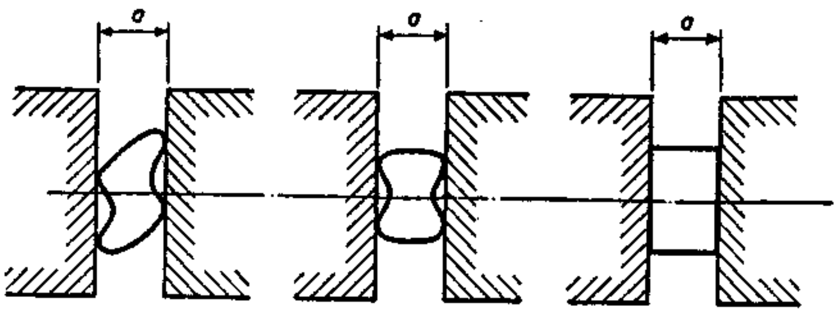

Fig. 3. Positioning of non-circular test pieces

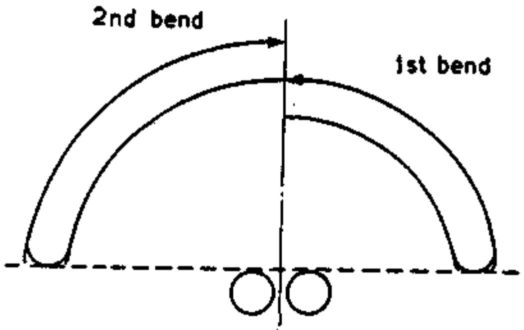

Fig. 4. Method of counting reverse bends

3.6.5 The wire shall then be bent through 90° in the opposite direction over the other cylindrical former and back to the vertical position. This process is continued in alternate directions until complete fracture occurs.

3.6.6 With the method of counting given in 3.6.4, the bend in which the wire fractures is only counted if the break occurs when the wire is being bent back to the vertical position.

3.6.7 If the testing machine has an automatic counter operating at the limit stops, then the first bend down through 90° counts as one bend and the second bend is represented by the 180° bend in the opposite direction.

3.6.8 Subsequent bends are counted for each 180° movement; but the bend in which fracture occurs is not counted.

3.6.9 The bending process shall be performed evenly without significant pause between bends and at a steady rate, avoiding any excessive temperature rise.

Unless otherwise specified, the rate of testing shall be one reverse bend per second.

3.7 MAINTENANCE OF TESTING MACHINE

3.7.1 For reliability in test results, it is essential that bend testing equipment be maintained in good condition.

3.7.2 Regular attention should be given to the pivot of the operating handle and to the guide arm to prevent slackness.

3.7.3 Height of limit stops and the 0·1 mm projection of the gripping faces should be checked when necessary.

4. WRAPPING TEST

4.1 GENERAL

4.1.1 There is no limit to the size of wire which may be subjected to a wrapping test but, unless special equipment is available, it is not readily applicable to sizes larger than about 5 mm.

4.1.2 Unless otherwise specified, the test shall be carried out at ambient temperature.

4.2 PRINCIPLE OF TEST

The test consists of winding the wire a specified number of turns around a core of specified diameter. The test may also include a requirement for the unwinding of a specified number of turns. The test is an indication of the ductility of the steel wire and should not be confused with the wrapping test for the adhesion of zinc on galvanized steel wire.

4.3 TEST PIECE

The wire need not be straightened before testing, if taken from a coil of wire, but shall be straightened if removed from a fabricated product.

4.4 TESTING MACHINE

A simple lathe or a torsion testing machine may be used for carrying out the test. Where the wrapping test has to be carried out around a mandrel of the same diameter as the wire, a piece of wire may be used to provide the mandrel.

4.5 PROCEDURE

4.5.1 The test piece shall be closely coiled round the mandrel at a constant speed, not exceeding 1 turn per second, but in any case sufficiently slowly to prevent any rise in temperature likely to affect the result of the test. It is usual to rotate the mandrel around its longitudinal axis with the leading end of the wire fixed to some point on the mandrel. This then causes the wire to be coiled on the mandrel. To ensure that the wire is closely coiled, back tension may be applied to the wire.

4.5.2 If unwrapping is specified, the above procedure is reversed and at the completion of unwrapping, at least 1 turn of wire shall remain wrapped around the mandrel.

4.5.3 The normal test requirement is that the wire shall not fracture during the course of the test.