Specification for

Stainless steel wire for mechanical springs

Fils pour ressorts en acier inoxydable à usage industriel — Spécifications

Federdraht aus rostfreiem Stahl für den Maschinenbau

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/26, upon which the following bodies were represented:

Aluminium Federation
Bicycle Association of GB
British Cable Makers' Confederation
British Rubber Manufacturers' Association
British Steel Industry
Federation of Wire Rope Manufacturers of Great Britain
Forestry Commission
Health and Safety Executive
Sheffield Stainless Steel Manufacturers' Association
Society of Chain Link Fencing Manufacturers
Society of Motor Manufacturers and Traders Limited
Spring Research and Manufacturers' Association
Stainless Steel Fabricators' Association of Great Britain
Stainless Steel Wire Industry Association
Welding Manufacturers Association (BEAMA Ltd.)
Woven Wire Association
Zinc Development Association

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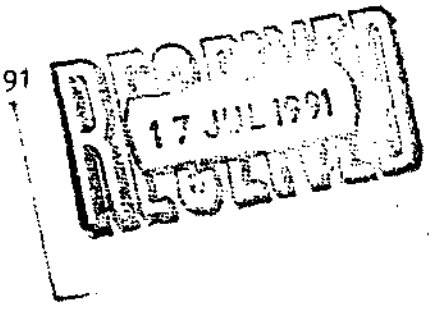


To Members of:

Technical Committee
ISM/26
Steel Wire

Sub Committee
ISM/26/2
Steel Wire for Fasteners

Panel Committee
ISM/26/1
Low Tensile Steel Wire

Dear Member

BS 2056:1991

British Standard Specification for Stainless Steel Wire for Mechanical Springs.

Gr 6

The above publication is now available and we enclose a copy with our compliments. We are very grateful for the help and co-operation of the committees concerned with its preparation and would like to thank you for your part in this work.

A copy has also been sent to interested technical and trade associations with the request that they bring it to the notice of their members. We shall be glad of any help you can give in making this and other BSI publications widely known.

Yours sincerely

Director General

Contents

Foreword

This British Standard has been revised under the direction of the Iron and Steel Standards Policy Committee and supersedes BS 2056 : 1983, which is withdrawn. It makes provision for the supply of a type of martensitic stainless steel and a selection of types of austenitic stainless steel most commonly used in the manufacture of springs including steels with low magnetic permeability. A type of precipitation hardening steel is also included.

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

Specification

1 Scope

This British Standard specifies the requirements for stainless steel wire, in diameters up to and including 10 mm, supplied in coils, on reels or in straight lengths, suitable for the manufacture of mechanical springs.

Specific requirements are given for six types of austenitic (301S26, 302S26, 316S33 and 316S42), including two types of low magnetic permeability (305S11 and 904S14), one type of martensitic (420S45) and one type of precipitation hardening (301S81) stainless steel spring wire.

In addition to the definitive requirements, this standard also requires the items detailed in clause **2** to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

NOTE 1. The titles of the publications referred to in this standard are listed on the inside back cover.

NOTE 2. For the purposes of this British Standard the term 'reel' is synonymous with the terms 'spool' and 'bobbin'.

2 Information and requirements to be agreed and to be documented

The following information to be supplied by the purchaser shall be fully documented.

Both the definitive requirements specified throughout the standard and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified:

(a) the number of this British Standard, i.e. BS 2056;

(b) the steel type number (see table 1);

(c) the nominal diameter of the wire (in mm);

(d) the tensile strength grade, if 301S26 or 302S26 is being ordered (see table 4);

(e) the form of supply, i.e. coils, reels, or straight lengths;

(f) any applicable requirements from the appropriate clauses for:

(1) surface finish and condition of wire (see clause **4**);

(2) packing and identification (see clauses **6** and **11**);

(g) any other special requirements.

3 Manufacture

3.1 Steelmaking process

The steel shall be made by an electric furnace process.

3.2 Chemical composition

The cast analysis shall comply with the composition ranges given in table 1 for the appropriate steel type. On request, the wire manufacturer shall supply the cast analysis. Any subsequent analytical checks on the product shall take into consideration the heterogeneity normal to the steel and shall be in accordance with appendix A.

3.3 Freedom from defects

3.3.1 The ingots, blooms or billets shall be so prepared as to remove surface imperfections that might produce defects in the wire made from them.

3.3.2 The rod from which the wire is drawn shall be free from harmful surface defects, pipe and other flaws (see also **4.1** for finished wire).

Table 1. Chemical composition of stainless steels (cast analysis)

Steel type	C		Si	Mn	P	S	Cr		Mo		Ni		Al		Cu		N
	min.	max.	max.	max.	max.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	max.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
301S26	—	0.15	1.00	2.00	0.045	0.030	16.0	18.0	—	—	6.0	8.0	—	—	—	—	—
302S26	—	0.12	1.00	2.00	0.045	0.030	17.0	19.0	—	—	7.5	10.0	—	—	—	—	—
316S33	—	0.07	1.00	2.00	0.045	0.030	16.5	18.5	2.5	3.0	11.0	14.0	—	—	—	—	—
316S42	—	0.07	1.00	2.00	0.045	0.030	16.0	18.5	2.00	2.50	9.50	13.50	—	—	—	—	—
305S11	—	0.03	1.00	2.00	0.045	0.030	17.0	19.0	—	—	11.0	13.0	—	—	—	—	—
904S14	—	0.03	1.00	2.00	0.030	0.040	19.5	22.0	4.00	5.00	24.0	27.0	—	—	1.00	2.00	0.06
301S81	—	0.09	1.00	1.00	0.045	0.030	16.0	18.0	—	—	6.50	7.75	0.75	1.50	—	—	—
420S45	0.28	0.36	1.00	1.00	0.040	0.030	12.0	14.0	—	—	—	1.00 max.	—	—	—	—	—

4 Condition of finished wire

4.1 The wire shall be free from harmful surface defects.

4.2 The wire shall be supplied in the appropriate condition as given in table 2.

NOTE. When specified by the purchaser, wire may be supplied with a metallic or other coating as an aid to forming operations. These coating requirements should be agreed between the manufacturer and the purchaser.

Table 2. Condition of finished wire

Type of steel		Condition
Austenitic	301S26 302S26	Cold drawn or cold drawn and polished
Austenitic (medium magnetic permeability)	316S33 316S42	Cold drawn or cold drawn and polished
Austenitic (low magnetic permeability)	305S11 904S14	Cold drawn or cold drawn and polished
Precipitation hardening	301S81	Cold drawn or cold drawn and polished
Martensitic	420S45	Free from scale, softened or cold drawn

5 Low magnetic permeability austenitic stainless steels

Austenitic stainless steels, 305S11 and 904S14 in the as drawn fully hardened spring temper condition, shall exhibit low magnetic permeability as given in table 3.

NOTE. The magnetic permeability of 305S11 can be further reduced by stress relieving the as drawn wire.

Table 3. Magnetic permeability of 305S11 and 904S14

Type of steel	Hard as drawn	Stress relieved 400 °C
305S11	1.0105	1.0055
904S14	1.0070	—

6 Method of supply

The wire shall be supplied in one of the following forms:

(a) in coils;

(b) on reels;

(c) in straightened and cut lengths (only applicable to wire of 0.25 mm diameter and larger).

NOTE. The tolerance on straightness of the cut lengths should be agreed between manufacturer and purchaser.

7 Sampling for mechanical tests

7.1 General

All tests shall be made on test pieces taken from the wire in the condition in which it is to be supplied to the purchaser. Apart from any straightening of the test lengths prior to testing, they shall not be treated in any way which may make them unrepresentative of the bulk of which they are a sample. Sampling shall be in accordance with **7.2**, **7.3** or **7.4**, as appropriate.

NOTE. See clause 10 for retests.

7.2 Coils

A test piece shall be taken from each end of every coil. If small coils are split from parent coils, samples tested from either end of the parent coil will be considered representative providing the coils can be identified to the parent coil.

7.3 Reels

A test piece shall be taken from the free outside end of the wire on every reel.

7.4 Straight lengths

Wire supplied in straight lengths shall be grouped in a bundle or bundles clearly identified with the coil or coils from which the lengths were cut. Two test pieces shall be selected at random from the lengths as being representative of the product of that coil or wire.

8 Mechanical properties

8.1 Tensile strength

8.1.1 When supplied in coils or reels and tested in accordance with BS 4545, the tensile strength shall comply with the range appropriate to the type, grade and wire diameter given in tables 4, 5 or 6, or the maximum values in table 7.

Table 4. Tensile strengths of 301S26, 302S26, 316S33 and 316S42 wire

Diameter		Tensile strength									
		Type 301S26				Type 302S26				Types 316S33 and 316S42	
Over	Up to and including	Grade I		Grade II		Grade I		Grade II			
		min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
mm	mm	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
0	0.2	1920	2200	2200	2450	1880	2160	2160	2400	1680	1920
0.2	0.4	1840	2100	2100	2350	1800	2060	2060	2300	1640	1880
0.4	0.7	1750	2000	2000	2240	1720	1960	1960	2200	1600	1840
0.7	1.0	1650	1900	1900	2140	1620	1860	1860	2100	1580	1820
1.0	1.5	1560	1800	1800	2050	1530	1770	1770	2010	1550	1790
1.5	2.0	1460	1700	1700	1950	1430	1670	1670	1910	1460	1700
2.0	2.8	1360	1600	1600	1850	1330	1570	1570	1810	1360	1600
2.8	4.0	1250	1500	1500	1740	1230	1470	1470	1710	1260	1500
4.0	6.0	1200	1450	1400	1640	—	—	1370	1610	1100	1340
6.0	8.0	—	—	1300	1550	—	—	1280	1520	1030	1270
8.0	10.0	—	—	1250	1500	—	—	1230	1470	860	1100

Table 5. Tensile strength of 301S81 wire

Diameter		Tensile strength			
Over	Up to and including	As supplied in the cold drawn condition		After heat treatment (see 8.1.2)	
		min.	max.	min.	max.
mm	mm	N/mm^2	N/mm^2	N/mm^2	N/mm^2
0.25	0.32	1880	2110	2230	2530
0.32	0.40	1860	2090	2210	2510
0.40	0.56	1820	2050	2170	2470
56	0.70	1800	2030	2150	2450
0.70	1.00	1770	2000	2120	2420
1.00	1.30	1710	1940	2030	2330
1.30	1.70	1650	1880	1970	2270
1.70	2.20	1630	1860	1930	2210
2.20	2.80	1560	1790	1860	2140
2.80	3.40	1500	1730	1800	2080
3.40	4.00	1460	1690	1760	2040
4.00	4.50	1420	1650	1720	2000
4.50	5.50	1400	1630	1680	1950
5.50	6.00	1380	1610	1660	1930
6.00	7.50	1350	1580	1600	1870
7.50	8.00	1330	1560	1530	1800
8.00	10.00	1270	1500	1470	1740

Table 6. Tensile strengths of 305S11 and 904S14 wire

Diameter		Tensile strength			
		Type 305S11		Type 904S14	
Over	Up to and including	min.	max.	min.	max.
mm	mm	N/mm^2	N/mm^2	N/mm^2	N/mm^2
0	0.2	1580	1820	1600	1800
0.2	0.4	1540	1780	1550	1750
0.4	0.7	1500	1740	1450	1650
0.7	1.0	1480	1720	1400	1600
1.0	1.5	1450	1690	1350	1550
1.5	2.0	1360	1600	1300	1500
2.0	2.8	1260	1500	1300	1500
2.8	4.0	1160	1400	1300	1500
4.0	6.0	1010	1250	1250	1450
6.0	8.0	940	1180	1200	1400
8.0	10.0	770	1010	1150	1350

Table 7. Tensile strength of 420S45 wire

Condition	Tensile strength
	N/mm^2
Softened	770 max.
Cold drawn	850 max.

NOTE. It is necessary to harden and temper 420S45 wire, after spring forming, in order to develop the required mechanical strength and corrosion resistance.

For material supplied in straight lengths, the stated values of tensile strength given in tables 4, 5, 6 and 7 shall be reduced by up to 10 %.

8.1.2 After heat treatment at 480 °C for 1 h, followed by cooling in air, the heat treated tensile strength of 301S81 wire shall be as given in table 5.

8.1.3 Martensitic stainless steel wire type 420S45 shall be supplied in the softened or in the cold drawn condition to the tensile strength values given in table 7.

8.2 Wrapping

The wrapping test shall be applied to all types of wire up to but not including 3 mm diameter in accordance with BS 4545. The wire shall not show sign of fracture when coiled eight complete turns around a mandrel of diameter equal to that of the wire (see clause **10**).

8.3 Flexibility

A single U bend test shall be applied to wire of 3.00 mm and larger diameters.

When tested in accordance with BS 4545 and appendix B the wire shall not show sign of failure (see clause **10**).

To avoid the need for an excessive number of sizes of mandrel, the wire shall be deemed to have complied with this standard if it is bent around a mandrel smaller than that specified.

8.4 Wire cast

NOTE 1. Details of wire cast measurement are given in appendix C.

8.4.1 *Circular cast*

When measured in accordance with C.2, wire from a reel shall take up a circular cast of diameter not less than barrel diameter of the reel and not more than 2.5 times the barrel diameter.

When measure in accordance with C.2, wire from a coil shall take up a circular cast of diameter not less than that of the original coil diameter and not more than 1.5 times the original coil diameter.

NOTE 2. For certain requirements, wire may be required to pay out approximately straight and in such circumstances the requirements for cast should be agreed between the manufacturer and the purchaser at the time of ordering.

8.4.2 *Helix cast*

When tested in accordance with C.3, the helix of a complete wap of wire, measured as the offset between the two ends of the wire, shall not exceed the values given in table 8.

Table 8. Values of helix

Wire diameter		Offset maximum
Over	Up to and including	
mm	mm	mm
0	0.40	60
0.40	1.00	80
1.00	1.75	90
1.75	10.00	100

8.4.3 *Spiral cast*

When tested in accordance with C.4, the wap of wire shall not show spiral cast.

9 Dimensional tolerances

9.1 Diameter tolerance and ovality

The minimum and maximum diameters shall be measured at the same cross section on a straight wire. Each measurement shall be within the tolerance for diameter and ovality given in table 9 for the appropriate diameter of wire.

NOTE. Ovality is defined as the difference between the minimum and maximum diameters of the wire at the same cross section.

Table 9. Tolerances on diameter and ovality

Diameter		Diameter tolerance		Maximum ovality	
Over	Up to and including	Coil or reel	Lengths	Coil or reel	Lengths
mm	mm	mm	mm	mm	mm
0.08	0.20	± 0.005	± 0.005	0.005	0.005
0.20	0.50	± 0.008	± 0.008	0.008	0.008
0.50	0.80	± 0.010	± 0.010	0.010	0.010
0.80	1.40	± 0.014	± 0.014	0.014	0.014
1.40	1.90	± 0.020	± 0.030	0.020	0.030
1.90	3.20	± 0.024	± 0.034	0.024	0.034
3.20	5.60	± 0.030	± 0.040	0.030	0.040
5.60	8.50	± 0.040	± 0.050	0.040	0.050
8.50	10.00	± 0.050	± 0.070	0.050	0.070

9.2 Straight length tolerances

When supplied in straight lengths, the lengths shall be not less than those given in the order and shall be within the tolerances given in table 10.

Table 10. Tolerances on length of straight lengths

Length	Tolerance
mm	mm
> 0 ≤ 160	—
> 160 ≤ 315	$^{+2}_{-0}$
> 315 ≤ 500	$^{+3}_{-0}$
> 500 ≤ 800	$^{+4}_{-0}$
> 800 ≤ 1250	$^{+5}_{-0}$
> 1250 ≤ 2000	$^{+7}_{-0}$
2000	$^{+13}_{-0}$

NOTE. Tolerances on length of straight lengths less than or equal to 160 mm should be agreed at the time of the enquiry and order.

10 Retests

10.1 General

If any test piece fails any of the tests, additional pieces for retest shall be taken from the appropriate coil, reel or bundles of lengths representing the product of a coil in accordance with **10.2**, **10.3** or **10.4**, as appropriate.

10.2 Coils

For wire in coil, two additional test pieces shall be taken from the end from which the previous test was taken (see **7.2**).

NOTE. Part of the coil may be discarded before taking the new test pieces.

10.3 Reels

For wire supplied in reels, two additional test pieces shall be taken from the free end of the wire (see **7.3**).

10.4 Straight lengths

For wire supplied in straight lengths, four additional test pieces shall be taken at random from the same bundle or bundles representing the product of the coil (see **7.4**).

10.5 Results

If the additional test pieces pass all the tests, the appropriate coil, reel or bundles representing the product of the coil shall be deemed to comply with this standard. If any of them fail, the coil, reel or corresponding bundles shall be deemed not to comply with this standard.

11 Packing and marking

Consignments of wire shall be suitably protected against mechanical damage and corrosion during transport.

NOTE. If special protection is required this should be agreed at the time of enquiry or order.

Wire in coils or bundles of lengths shall be securely tied.

All consignments shall carry a suitable label or labels on which the following shall be clearly shown:

(a) the number and date of this British Standard, i.e. BS 2056 : 1991[1)];

(b) the steel type number;

(c) the nominal diameter of the wire (in mm);

(d) tensile strength grade (for 301S26 and 302S26);

(e) whether softened or cold drawn (for 420S45);

(f) the manufacturer's name;

(g) any other information agreed between manufacturer and purchaser.

[1)] Marking BS 2056 : 1991 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a declaration is not to be confused with third party certification of conformity, which may also be desirable.

Appendices

Appendix A. Product analysis and permitted variations

A.1 Analysis of the product may vary from the cast analysis owing to the heterogeneity arising during the casting and solidification of the ingot. Table 11 shows the permitted variations in product analysis.

Table 11. Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element fails	Variation of specified range	
		Over maximum	Under minimum
	%	%	%
C	≤ 0.03	0.005	
	> 0.03 ≤ 0.25	0.01	0.01
	> 0.25 ≤ 0.50	0.02	0.02
Si	≤ 1.0	0.05	0.05
	> 1.0	0.07	0.07
Mn	≤ 1.0	0.03	0.03
	> 1.0 ≤ 2.0	0.04	0.04
P	> 0.030 ≤ 0.045	0.004	—
S	≤ 0.030	0.003	—
Cr	> 10.0 ≤ 15.0	0.15	0.15
	> 15.0 ≤ 20.0	0.20	0.20
	> 20.0	0.25	0.25
Mo	> 2.0 ≤ 3.0	0.08	0.08
	> 3.0 ≤ 5.0	0.10	0.10
Ni	≤ 1.0	0.03	0.03
	> 5.0 ≤ 10.0	0.10	0.10
	> 10.0 ≤ 20.0	0.15	0.15
	> 20.0	0.20	0.20
Al	≤ 1.50	0.10	0.10
Cu	All ranges	0.10	0.10

The variations may occur either above or below the individual element ranges but shall not be applied both above and below the specified range for any one element in any one cast of steel.

A.2 If the product analysis of any wire falls outside the limits of acceptable variation from the specified composition range for a significant element, that wire shall be deemed not to comply with this standard, and further samples shall be selected for check analysis from the remainder of the consignment, as follows:

(a) at least two samples from the same cast, for consignments up to and including 5 t;

(b) at least five samples from the same cast, for consignments up to and including 20 t;

(c) at least eight samples from the same cast, for consignments over 20 t.

The results of the analysis of these samples shall fall within the permitted variations. If any of these further samples are proved to be outside the permitted variations for any element, the consignment shall be deemed not to comply with this standard.

A.3 Samples for product analysis shall be taken in accordance with BS 1837 and, in the event of dispute, analysed in accordance with the appropriate methods of BS 6200.

Appendix B. Bend test

B.1 In carrying out the test, the wire shall be free to move longitudinally in the forming device.

B.2 Bend the wire through 180 ° to form a U around a mandrel of diameter equal to twice the wire diameter for wire diameters from 3.00 mm to 6.00 mm and equal to three times the wire diameter for wire diameters over 6.00 mm.

Appendix C. Wire cast measurement

C.1 General

C.1.1 The cast of wire is characterized by the diameter of the free laying unrestrained wap of wire taken from coil or reel. For coil, ends can be together (closed cast) or apart (open cast).

NOTE. For retests, see clause 10.

C.1.2 Sufficient wire from a coil or reel is cut off to produce a full free wap (single convolution of wire) ensuring that it is not bent or damaged (see figure 1).

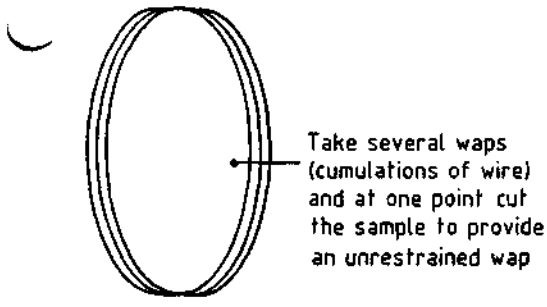


Figure 1. Sampling of wire

C.2 Circular ring cast

To measure circular cast, being the inside diameter of the wap, place the wap on a flat horizontal surface and measure the average diameter. (See figures 2 and 3 which also show the definition of closed and open circular cast.)

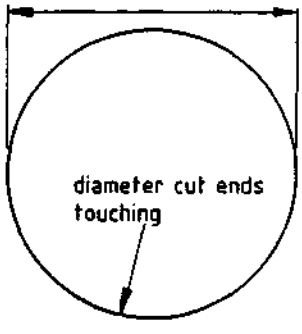


Figure 2. Closed circular cast

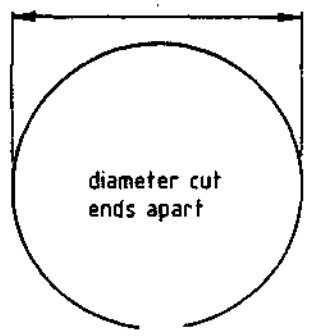
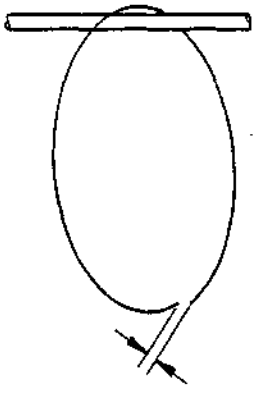


Figure 3. Open circular cast

C.3 Helix cast

To measure the displacement of the cut ends at right angles to the wap suspend the wap from the mid-point of a piece of rod or a pencil, etc., so that the cut ends are at the lowest point and the two ends hang free diametrically below the point of suspension. Measure the separation of the ends at right angles to the plane of the wap (see figure 4).



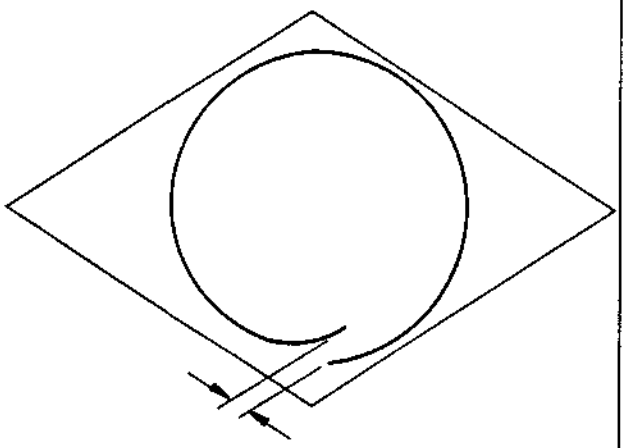
NOTE. Wap is suspended vertically and horizontal displacement of cut ends (cast open or closed) is measured.

Figure 4. Helix : vertical placement

C.4 Spiral cast

To assess spiral cast, place the wap on a flat horizontal surface and check whether there is any horizontal displacement between the ends of the wap (see figure 5).

NOTE. Spiral cast is the term used when one end of the wap is curling inside the natural diameter of the wap. It is possible that a wap of wire in this condition will also exhibit vertical displacement (helix) (see figure 4).



NOTE. Wap is laid on flat surface and any horizontal displacement of cut ends is assessed.

Figure 5. Spiral cast

Publication(s) referred to

BS 1837 Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys
BS 4545 Methods for mechanical testing of steel wire
BS 6200 Sampling and analysis of iron, steel and other ferrous metals

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

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A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Revisions

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