BRITISH STANDARD

BS 3111-1:1987

Incorporating
Amendment No. 1

Steel for cold forged fasteners and similar components —

Part 1: Specification for carbon and low alloy steel wire

UDC 669.14:621.88

Committees responsible for this British Standard

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

British Steel Industry
British Steel Industry (Wire Section)
British Wire Netting Association
Fencing Contractors' Association
Society of Chain Link Fencing Manufacturers
Welding Manufacturers Association (BEAMA Ltd.)

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

BEAMA Ltd.
British Industrial Fasteners Federation
Society of Motor Manufacturers and Traders Limited
Stainless Steel Wire Export Group

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Contents

Foreword

This Part of BS 3111 has been prepared under the direction of the Iron and Steel Standards Committee and is a revision of BS 3111-1:1977 which is withdrawn.

In this revision the number of alloy steels has been reduced and provisions in respect of decarburization and mechanical properties have been updated. Chemical composition and properties of boron steels have also been updated. Part 2 of BS 3111 specifies stainless steel wire.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 10, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 3111 specifies requirements for steel wire up to and including 30 mm diameter for use in the manufacture of low, medium and high tensile, cold forged fasteners and similar components in the following eight types of steel.

0 low carbon steel
1 medium carbon steel
2 carbon-molybdenum steel
3 1 % chromium steel
5 1 % chromium-molybdenum steel
7 1/2 % nickel-chromium-molybdenum steel
9 low carbon-manganese-boron steel
10 medium carbon-manganese-boron steel

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

2 Designation

The designation shall consist of the following items in the order given:

a) the number of this British Standard, i.e. BS 3111-1;

b) the type number and grade number of steel required (see Table 2);

c) the abbreviation COND and one of the following letters denoting the delivery conditions:

A denotes drawn to size and finally spheroidize annealed;
B denotes drawn, spheroidize annealed and finally light drawn;
C denotes spheroidize annealed and finally light drawn;
D denotes direct drawn.

d) the abbreviation GR and the number denoting the grade of decarburization required (see Clause **7**).

Examples of this designation are as follows:

1) BS 3111-1 9/2 COND A GR3

2) BS 3111-1 0/1 COND B

3 Information to be supplied by the purchaser

3.1 General

The following information shall be supplied by the purchaser at the time of enquiry and order.

a) the complete designation as covered by clause **2**;

b) the nominal, maximum or minimum diameter required (see clause **12**);

c) the coil mass with inside and outside diameters.

NOTE If coatings are required the type of coating to be applied, its mass or thickness and method of measurement should be agreed at the time of the enquiry and order.

3.2 Options

A number of options are specified in appendix A. In the event that the purchaser does not indicate his wish to implement any of these options and specify his requirements at the time of the enquiry and order, the manufacturer shall supply in accordance with the basic specification.

4 General

The wire shall comply with the general requirements of this standard and the appropriate specific requirements for the steel type and grade. Where any of the options given in appendix A are called up at the time of the enquiry and order, the wire shall, in addition, comply with the requirements of any such options.

5 Steelmaking process

The steel making and casting process shall be any process except the Bessemer process.

See also option **A.1**.

6 Freedom from defects

The steel shall be free from pipe and from such segregation and surface defects as might preclude its use for the purpose for which it is intended.

See also option **A.2**.

7 Decarburization

7.1 The requirements of **7.2** and **7.3** shall not apply to steel type 0 except type 0/4.

7.2 Decarburization shall be determined by microscopic examination as described in BS 6617-1.

NOTE The definitions of decarburization are as given in BS 6617-1.

7.3 Decarburization shall be one of the four grades given in Table 1.

For grade 1, no complete decarburization shall be present. The depth of partial decarburization at any point on the periphery shall not exceed the value in Table 1.

For grades 2, 3 and 4, the average total decarburization shall not exceed the value in Table 1. The depth of decarburization obtained at the maximum decarburization position shall not exceed the average value in Table 1 by more than 50 %.

7.4 The steel shall not be surface carburized. Where it is suspected that there is surface carburization the method described in appendix C shall be used for detection.

Table 1 — Permitted depths of decarburization

Nominal diameter of wire		Depth of total decarburization			
Over	Up to and including	Maximum	Average		
		Grade 1	Grade 2	Grade 3	Grade 4
mm	mm	mm	mm	mm	mm
—	6.5	0.080	0.060	0.080	0.130
6.5	8.0	0.080	0.080	0.100	0.150
8.0	9.5	0.100	0.080	0.130	0.180
9.5	11.0	0.130	0.100	0.150	0.200
11.0	13.0	0.130	0.130	0.180	0.230
13.0	16.0	0.160	0.160	0.210	0.260
16.0	19.0	0.190	0.190	0.250	0.300
19.0	22.0	0.220	0.220	0.300	0.350
22.0	25.0	0.250	0.250	0.300	0.350
25.0	30.0	0.280	0.280	0.300	0.350

8 Chemical composition

8.1 Ladle analysis

The chemical composition of the steels shall be determined by ladle analysis and shall be as given in Table 2.

For steel types 9/1 and 10/1, the total content of nickel plus chromium plus molybdenum shall not exceed 0.2 %.

See also options **A.3**, **A.4**, **A.5** and **A.6**.

8.2 Product analysis

The permitted deviations from the specified range for the product analysis shall be as given in Table 3 and Table 4. The deviations shall apply either above or below the individual element ranges, but not both above and below the range for any one element in any one cast of steel.

8.3 Samples

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 Handbook No. 19 or BS 6200 as appropriate.

Table 2 — Chemical composition (ladle analysis)

Steel type and grade	Element								
	C	Si	Mn	P	S	Cr	Mo	Ni	B (total)
	%	%	%	%	%	%	%	%	%
0	—/0.25	—/0.40	0.25/1.00	—/0.050	—/0.050				
0/1	—/0.15	—	—/0.70	—/0.050	—/0.050				
0/2	—/0.15	—/0.40	—/0.70	—/0.050	—/0.050				
0/3	0.13/0.18	—/0.40	0.50/1.00	—/0.050	—/0.050				
0/4	0.18/0.23	—/0.40	0.50/1.00	—/0.050	—/0.050				
1/1	0.30/0.35	0.10/0.35	0.70/1.00	—/0.035	—/0.035				
1/2	0.35/0.40	0.10/0.35	0.70/1.00	—/0.035	—/0.035				
1/3	0.40/0.45	0.10/0.35	0.70/1.00	—/0.035	—/0.035				
2/1	0.35/0.40	0.15/0.40	0.70/0.90	—/0.035	—/0.035		0.20/0.30		
2/2	0.40/0.45	0.15/0.40	0.80/1.00	—/0.035	—/0.035		0.25/0.35		
3/1	0.35/0.40	0.15/0.40	0.70/0.90	—/0.035	—/0.035	0.90/1.20			
3/2	0.40/0.45	0.15/0.40	0.70/0.90	—/0.035	—/0.035	0.90/1.20			
5/1	0.35/0.40	0.15/0.40	0.70/0.90	—/0.035	—/0.035	0.90/1.10	0.15/0.25		
5/2	0.38/0.43	0.15/0.40	0.70/0.90	—/0.035	—/0.035	0.90/1.10	0.15/0.25		
7	0.38/0.43	0.15/0.40	0.75/1.00	—/0.035	—/0.035	0.40/0.60	0.20/0.30	0.40/0.70	
9/0[a]	0.15/0.20	—/0.40	0.60/0.90	—/0.035	—/0.035				0.0008/0.005
9/1[a]	0.17/0.23	—/0.40	0.75/0.95	—/0.035	—/0.035	[b]	[b]	[b]	0.0008/0.005
9/2[a]	0.17/0.23	—/0.40	0.85/1.05	—/0.035	—/0.035	0.15/0.30			0.0008/0.005
9/3[a]	0.17/0.23	—/0.40	0.95/1.15	—/0.035	—/0.035	0.15/0.30			0.0008/0.005
10/1[a]	0.32/0.39	—/0.40	0.70/1.00	—/0.035	—/0.035	[b]	[b]	[b]	0.0008/0.005
10/2[a]	0.32/0.39	—/0.40	0.80/1.10	—/0.035	—/0.035	0.15/0.30			0.0008/0.005

[a] Boron steels require special deoxidation practices and aluminium and titanium are normally used to prevent combination with other elements.
[b] See **8.1**.

Table 3 — Permitted deviations in product analysis from specified range: carbon steels types 0 and 1 and boron-treated steels types 9 and 10

Element	Range in which the maximum of specified element falls	Deviations from specified range	
		Over maximum	Under minimum
	%	%	%
Carbon	Rimmed steels only all carbon contents	0.02	0.07
Carbon	Killed steels only		
	up to and including 0.25	0.02	0.02
	over 0.25 up to and including 0.45	0.03	0.03
Silicon	Killed steels only		
	up to and including 0.40	0.03	0.03
Manganese	Up to and including 1.0	0.04	0.04
	over 1.0 up to and including 1.15	0.08	0.08
Phosphorus	Up to and including 0.025	0.005	—
	over 0.025 up to and including 0.040	0.006	
	over 0.040 up to and including 0.050	0.008	
Sulphur	Up to and including 0.025	0.005	—
	over 0.025 up to and including 0.040	0.006	
	over 0.040 up to and including 0.050	0.008	
Boron	Over 0.0008 up to and including 0.005	0.0003	0.0003
Chromium	Up to and including 0.30	0.03	0.03

Table 4 — Permitted deviations in product analysis from specified range: alloy steels types 2, 3, 5 and 7

Element	Range in which the maximum of specified element falls	Deviations from specified range	
		Over maximum	Under minimum
	%	%	%
Carbon	Over 0.35 up to and including 0.45	0.02	0.02
Silicon	Over 0.15 up to and including 0.40	0.03	0.03
Manganese	Over 0.70 up to and including 1.0	0.04	0.04
Phosphorus	Up to and including 0.035	0.003	—
Sulphur	Up to and including 0.035	0.003	—
Chromium	Up to and including 0.60	0.03	0.03
	Over 0.60 up to and including 1.20	0.04	0.04
Molybdenum	Up to and including 0.35	0.02	0.02
Nickel	Up to and including 0.7	0.03	0.03

9 Mechanical tests

The mechanical properties of the wire shall be as given in Table 5.

If up to 5 % of the product delivered exceeds the tensile strength values given in Table 5 by no more than 20 N/mm^2 the wire shall still be deemed to comply with this standard.

Tensile tests on wire in the delivered condition shall be carried out in accordance with BS 18-2 for wires of diameter greater than 10 mm and in accordance with BS 4545 for wires 10 mm in diameter or less.

Tensile tests shall be carried out on test pieces that have not been subject to any preliminary machining.

Table 5 — Mechanical properties of wire

Steel type and grade	Tensile strength R_m (max.)						Reduction of area Z (min.)		
	Condition A	Condition B	Condition C		Condition D		Condition A	Condition B	Condition D
	All diameters	All diameters	> 5 ≤ 10 mm	> 10 mm	> 5 ≤ 10 mm	> 10 mm	All diameters	All diameters	All diameters
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	%	%	%
0/1	400	440	530	460	590	550	60	57	52
0/2	430	470	560	490	620	580	60	57	52
0/3	470	510	600	530	660	620	60	57	52
0/4	500	550	640	570	680	640	60	57	52
1/1	540	590[a]	690	620			60	57	
1/2	570	620[a]	720	650			59	54	
1/3	600	650[a]	770	700			59	54	
2/1	570	650	740	670			59	52	
2/2	600	670	770	700			57	52	
3/1	600	670	750	680			57	52	
3/2	610	680	780	710			55	52	
5/1	670	710	810	740			55	52	
5/2	700	740	840	770			55	52	
7	630	680	810	740			55	52	
9/0	490	540	630	560	690	630	60	57	52
9/1	500	550	640	570	700	640	60	57	52
9/2	510	560	650	580	710	650	60	57	52
9/3	520	570	660	590	720	660	60	57	52
10/1	550	600	720	650			59	54	
10/2	570	650	750	680			59	54	

[a] For diameters less than 7 mm add 30 N/mm^2.

10 Hardenability

Hardenability requirements shall be as given in Table 6 and Table 7.

Hardenability testing shall be carried out by Jominy testing at the billet stage in accordance with BS 4437. Method 1 shall be used for types 2 to 10 inclusive and method 2 for type 1 only.

See also option **A.7.**

11 Grain size

Type 0 steel shall be supplied without specific grain size control.

Steel types 1 to 10 shall have grain size 5 or finer in accordance with BS 4490.

See also option **A.8.**

Table 6 — Hardenability requirements

Steel type and grade		Jominy hardness HRC (min.)					Hardening test		
		Jominy position (mm)					Austenitizing temperature range	Hardness mid-radius at limiting diameter	
Number	Carbon range	3	5	7	9	13		HV 30 (min) average	Diameter (max)
0[a]	%						°C		mm
1/1[b]	0.30-0.35						850-880	400	12
1/2[b]	0.35-0.40						850-880	400	16
1/3[b]	0.40-0.45						850-880	400	20
2/1	0.35-0.40			35			840-860	450	15
2/2	0.40-0.45			40			840-860	475	20
3/1	0.35-0.40				40		850-880	475	20
3/2	0.40-0.45				45		850-880	475	24
5/1	0.35-0.40					43	850-880	550	24
5/2	0.38-0.43					47	850-880	550	24
7	0.38-0.43				47		840-860	550	24
9/0	0.15-0.20	36					900-930	350	12
9/1	0.17-0.23	38					900-930	400	12
9/2	0.17-0.23		38				900-930	400	20
9/3	0.17-0.23			38			900-930	400	24
10/1	0.32-0.39		44				870-900	450	20
10/2	0.32-0.39			44			870-900	450	24

[a] Hardenability requirements are not applicable to this steel unless specified at the time of enquiry and order.
[b] See Table 7.

Table 7 — Steel type 1: Jominy hardenability requirements

Steel type and grade	Carbon range	Jominy hardness HV 30 (min)				
		Jominy position (mm)				
		2.75	3.5	4.25	5.00	5.75
	%					
1/1	0.30-0.35	460		340		
1/2	0.35-0.40		450		350	
1/3	0.40-0.45			430		360

12 Tolerances on diameter

The tolerances on diameter shall be as given in Table 8. If a nominal diameter is specified the tolerance shall be half the total tolerance given in Table 8 over and under the nominal diameter.

If a maximum diameter is specified the tolerance shall be the total tolerance given in Table 8 all under the maximum diameter.

If a minimum diameter is specified the tolerance shall be the total tolerance given in Table 8 all over the minimum diameter.

Table 8 — Tolerances on diameter

Diameter of wire		Condition	
		A	B, C and D
Over	Up to and including	Total tolerances	Total tolerances
mm	mm	mm	mm
—	16	0.08	0.06
16	30	0.12	0.08

13 Marking

Each coil of wire shall bear a label, securely attached, giving the number and date of this British Standard, i.e. BS 3111-1:1987[1)], and the diameter, type, cast number and suppliers identification.

14 Test certificate

Products shall be supplied without a test certificate. See also option **A.9**.

[1)] Marking BS 3111-1:1987 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 should be addressed to the appropriate certification body.

Appendix A Options (see **3.2**)

A.1 Steelmaking process

The steelmaking process and/or casting process shall be specified by the purchaser (see clause **5**).

A.2 Defect levels

The purchaser shall specify tests and acceptable levels of surface defects using one of the methods given in appendix B.

A.3 Carbon range: steel types and grades 0, 0/1 and 0/2

Within the limits specified for carbon content in Table 2 the ladle analysis carbon range shall be 0.05 % as specified by the purchaser (see Table 2).

A.4 Manganese range: steel types and grades 0, 0/1, 0/2, 0/3, 0/4, 1/1, 1/2 and 1/3

Within the limits specified for manganese content in Table 2 the ladle analysis manganese range shall be 0.20 % as specified by the purchaser (see Table 2).

A.5 Silicon content, killed steel: steel types and grades 0, 0/2, 0/3 and 0/4

The ladle analysis silicon content shall be 0.10 % to 0.40 % (see Table 2).

A.6 Silicon content aluminium killed steel: steel types and grades 0, 0/2, 0/3 and 0/4

The ladle analysis silicon content shall be 0.10 % maximum (see Table 2).

A.7 Hardenability: wire of diameter up to and including 25 mm

A wire hardening test as described in appendix D shall be carried out instead of the Jominy test (see clause **10**).

A.8 Grain size

The purchaser shall specify the required grain size with reference to BS 4490 (see clause **11**).

A.9 Test certificate

The manufacturer shall supply a test certificate giving the ladle analysis, and the results of any mechanical or other tests (see clause **14**).

Appendix B Tests for surface defects

B.1 General

In the case of dispute the metallographic test described in **B.2** shall be the reference method.

B.2 Metallographic test

Mount a transverse section of wire and examine microscopically by bright field illumination at a magnification between × 100 and × 200. This test is suitable for all steel types.

B.3 Deep etch test

Immerse a piece of wire not less than 200 mm long for a period of ten minutes in a solution of equal volumes of concentrated hydrochloric acid (relative density 1.16 to 1.18) and water maintained at a temperature of not less than 86 °C. Remove from the solution and wash.

File any defect until it disappears, the difference in thickness before and after filing being recorded as the defect depth.

This test is suitable for all steel types.

B.4 Cold upset test

Upset a piece of wire of length equal to its diameter by compression at room temperature so that its length after compression is equal to half of the original diameter.

Examination of the test piece shall not reveal surface defects likely to prove detrimental in cold forging.

This test is suitable for all steel types greater than 5 mm diameter.

B.5 Reverse torsion test

Grip a piece of wire having a length of 200 mm at each end. Keep one end stationary and turn the other end the specified number of turns through 360° in one direction and then turn the same number of times 360° in the opposite direction.

The number of turns are given in Table 9.

Examination of the test piece shall not reveal surface defects likely to prove detrimental in cold forging.

This test is suitable only for type 0 steels up to 12 mm diameter except in condition D.

Appendix C Detection of surface carburization

Possible surface carburization may be detected optically in spheroidized materials by observation of surface pearlite or an increased number of carbide spheroids.

To confirm the presence of carburization, cut test specimens from the raw material and fully heat treat in a suitable protective atmosphere. Grind a transverse section, polish and etch in a 4 % nital solution. When examined microscopically a dark etching band indicates the possibility of carburization.

Once a suspect area has been located, a microhardness traverse will confirm the presence of carburization if the affected area is more than 1 point Rockwell "C" or 30 HV 0.3 greater than the unaffected area.

Appendix D Hardening test on steel wire for wire diameters not exceeding 25 mm

Place test pieces of finished wire not less than 150 mm long and of diameter not greater than 25 mm in a furnace containing a fully protective atmosphere at the temperature specified for the hardening test for steel types in Table 6.

After reaching the temperature of the furnace, maintain the test piece at that temperature for not less than 10 min. Quench in a well agitated conventional quenching oil kept at a temperature of 35 ± 10 °C.

Carry out the hardness test in accordance with BS 427-1 on the prepared surface of a transverse microsection taken from the approximate centre of the specimen. The hardness measurements shall be taken at four equidistant mid-radial positions; the average of the four readings shall be not less than the value specified in Table 6.

Table 9 — Number of turns in reverse torsion test

Carbon range	Up to and including 4 mm	Over 4 mm up to and including 6 mm	Over 6 mm up to and including 8 mm	Over 8 mm up to and including 12 mm
%				
0.09 to 0.19	14	12	10	8
0.20 to 0.25	12	10	8	6

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Publications referred to

BS 18, *Methods for tensile testing of metals.*
BS 18-2, *Steel (general).*
BS 427, *Method for Vickers hardness test.*
BS 427-1, *Testing of metals.*
BS 1837, *Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys.*
BS 4437, *Method for the end quench hardenability test for steel (Jominy test).*
BS 4490, *Methods for the determination of the austenitic grain size of steel.*
BS 4545, *Methods for mechanical testing of steel wire.*
BS 6200, *Sampling and analysis of iron, steel and other ferrous metals.*
BS 6617, *Determination of decarburization in steel.*
BS 6617-1, *Methods for determining decarburization by microscopic and micro-hardness techniques.*
BS Handbook No. 19 Methods for the sampling and analysis of iron, steel and other ferrous metals.

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