

Specification for

Wrought steel for mechanical and allied engineering purposes —

**Part 3: Bright bars for general
engineering purposes**

Committees responsible for this British Standard

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- Associated Offices Technical Committee
- British Chain Manufacturers' Association
- British Coal Corporation
- British Forging Industry Association
- British Industrial Fasteners Federation
- British Railways Board
- British Steel Industry
- Cold Rolled Sections Association
- Department of Trade and Industry (National Physical Laboratory)
- Engineering Industries Association
- Federation of British Engineers' Tool Manufacturers
- Lloyds Register of Shipping
- Ministry of Defence
- National Association of Steel Stockholders
- Road Vehicle Spring Society
- Society of Motor Manufacturers and Traders Limited
- Stainless Steel Fabricators' Association of Great Britain

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Foreword

This Part of BS 970 has been prepared under the direction of the Iron and Steel Standards Policy Committee. It supersedes those clauses concerned with bright finished bars in BS 970-1:1983, which is withdrawn.

Technical Committee ISM/31 has decided that requirements for bars supplied in the bright cold finished condition should be withdrawn from BS 970-1:1983 to appear in a separate standard for the sake of clarity and as a preparatory step towards a European Standard for this product range.

This Part of BS 970 specifies the requirements for bright cold finished bars in carbon, carbon manganese, alloy, free-cutting and stainless steels supplied in straight lengths.

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.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 30, 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 970 specifies requirements for carbon and carbon manganese, alloy, free-cutting and stainless steels normally supplied in the bright cold finished condition. It is only applicable to steels supplied in straight lengths.

In addition to the definitive requirements, this Part of BS 970 also requires the items detailed in clause 3 to be documented. For compliance with this Part of BS 970, both the definitive requirements and the documented items have to be satisfied.

Special ordering options to be called up as required by the purchaser are included in appendix A.

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

2 Definitions and symbols

2.1 Definitions

For the purposes of this Part of BS 970 the following definitions apply.

2.1.1

bright cold drawn bars

bars of various cross-sectional shapes obtained, after descaling, by drawing of hot rolled bars or rod, through a die (cold deformation without removing material)

NOTE This operation gives the product special features with respect to shape, dimensional accuracy and surface finish. In addition, the process causes cold working of the product, which can be eliminated by subsequent heat treatment. Products in lengths are delivered straightened regardless of size.

2.1.2

bright turned bars

bars of circular cross section having the special features of drawn product concerning shape, dimensional accuracy and bright surface finish with the additional benefit of metal removal on decarburization and surface defectiveness produced by turning

2.1.3

precision ground bars

drawn or turned bars of circular cross section given an improved surface finish and dimensional accuracy by grinding or grinding and polishing

2.1.4

annealing

heat treatment consisting of heating and soaking at a suitable temperature followed by cooling under conditions such that, after return to ambient temperature, the metal will be in a structural state closer to that of equilibrium

NOTE The heat treatments in 2.1.4 to 2.1.7 can be carried out either before or after cold conversion and can result in surface discolouration.

2.1.5

normalizing

heat treatment consisting of austenitizing followed by air cooling to refine the metallurgical structure (See note to 2.1.4.)

2.1.6

stress relieving

heat treatment including heating and soaking at a suitable temperature followed by cooling at an appropriate rate in order to relieve internal stresses without substantially modifying the structure (See note to 2.1.4.)

2.1.7

hardening and tempering

heat treatment including heating to a temperature above the upper critical temperature followed by rapid cooling by means of a suitable quenching medium and subsequent reheating to a temperature below the lower critical temperature (See note to 2.1.4.)

2.1.8

ruling section

the equivalent diameter of that portion of the product at the time of heat treatment that is most important in relation to mechanical properties

2.1.9

limiting ruling section

the largest diameter in which certain specified mechanical properties are achieved after a specified heat treatment

2.1.10

equivalent diameter

the diameter of a hypothetical bar of infinite length of uniform circular cross section which, if subjected to the same cooling conditions as the product, i.e. same initial and final temperature and same cooling medium, would have a cooling rate at its axis equivalent to that at the slowest cooling position in the product or relevant part

2.1.11

test sample

a sufficient quantity of material taken from the sample product for the purpose of producing one or more test pieces

2.1.12

test piece

part of the test sample, with the specified dimensions, machined or unmachined, brought to the required condition for submission to a given test

2.2

symbols

the symbols used in this Part of BS 970 are given in 1.3 of BS 970-1:1991

3 Information and requirements to be agreed and to be documented

3.1 Information to be supplied by the purchaser

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

Both the definitive requirements specified throughout this Part of BS 970 and the following documented items shall be satisfied before a claim of compliance with this Part of BS 970 can be made and verified:

- a) details of the form of section, size, length and quantity;
- b) the tolerances required on sections (see Table 1 to Table 4);
- c) the grade of steel required (see Table 5 and Table 6 and Table 12 to Table 28);
- d) the tolerances required on length;
- e) surface condition of supply (see clause 12 and Table 7 to Table 11);
- f) heat treatment condition together with any physical properties required (see Table 19 to Table 28);

3.2 Options

If the purchaser wishes to take up any of the optional requirements given in this Part of BS 970 (see appendix A), such requirements shall be specified at the time of the enquiry and/or order. In the absence of such information, the manufacturer shall supply in accordance with the basic specification.

3.3 Items for agreement

The following items to be agreed between the contracting parties, which are specified in the clauses referred to, shall be fully documented. Both the definitive requirements specified throughout this Part of BS 970 and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified.

- a) If controlled magnetic properties are required they shall be agreed at the time of enquiry and/or order (see 4.3.2).
- b) If bars shall be supplied with special corrosion protection it shall be specified and agreed at the time of enquiry and/or order (see 4.6).

c) If any particular type of deoxidation is required it shall be agreed at the time of enquiry and/or order (see 5.1).

d) If closer dimensional tolerances than those given in Table 1 to Table 4 are required they shall be agreed at the time of enquiry and/or order (see 6.4).

e) Results based on test bar sizes of 13 mm or 29 mm shall be agreed at the time of enquiry and/or order (see 7.3.1 and 10.4).

f) If mechanical properties other than those in a longitudinal direction are required values shall be agreed at the time of enquiry and/or order (see 7.4.2).

g) If a particular grain size range is required it shall be supplied and the method of measurement agreed at the time of enquiry and/or order (see 8.5).

h) If restrictions on certain elements in the chemical composition ranges are required this shall be agreed at the time of enquiry and/or order (see 9.1).

i) If controlled sulfur and phosphorus ranges other than those specified in Table 12 to Table 18 are required they shall be agreed at the time of enquiry and/or order (see 9.1).

j) If specific non-destructive testing is required the inspection technique and the inspection limits shall be agreed at the time of enquiry and/or order (see 12.1 and 12.3.1.4).

k) If specific cleanness requirements are required the relevant standard criteria shall be agreed at the time of enquiry and/or order (see 12.2).

l) If a maximum decarburization limit is required the level shall be agreed at the time of enquiry and/or order and measured in accordance with BS 6617-1 and BS 6617-2 (see 12.4).

m) If end stamping or colour coding is required it shall be agreed at the time of enquiry and/or order (see clause 13).

4 General

4.1 Steel products

Steel products shall comply with the specific requirements of this Part of BS 970 and with the specific requirements applicable to the grade concerned. Where any of the options given in appendix A are called up at the time of the enquiry and/or order, the steel products shall, comply with the requirements of any such options.

4.2 Carbon, carbon manganese, free-cutting and alloy steels

Where mechanical properties are obtained by heat treatment, the treatment given to the test bars and to material required in the finally heat treated condition shall be as given in Table 19 to Table 28. Unless otherwise specified at the time of enquiry and/or order bars supplied in the non-heat treated condition shall not be hardness tested. (See also option A.1.)

4.3 Stainless steels

4.3.1 Ferritic steels

When bright bars are supplied in the hardened and tempered condition, the heat treatment shall be given either before or after any cold sizing

NOTE Bright bars of ferritic steel supplied in the softened condition can be treated before or after any cold sizing.

4.3.2 Austenitic steels

When bright bars are supplied in the softened condition the heat treatment shall be given before drawing, turning or grinding.

NOTE If controlled magnetic properties are required, see 3.3 a).

4.3.3 Martensitic steels

Bright bars of martensitic steels shall be supplied in the condition given in Table 23.

4.4 Specific requirements of Table 12 to Table 28

The specific requirements given in Table 12 to Table 28 shall apply to the following:

a) close limits of chemical composition (A grades) where no mechanical or hardenability requirements are specified;

b) specified mechanical properties (M grades);

NOTE Variations from the specified chemical composition range are permissible provided that the stipulated mechanical properties are attained.

c) specified hardenability properties (H grades).

NOTE Properties given in the appropriate hot rolled steel bar standard will apply.

4.5 Cast analysis

The manufacturer shall supply a certificate stating the cast analysis of the material. (See also option A.2)

4.6 Corrosion protection

The manufacturer shall supply bars with a coating of a corrosion protection medium. (See also 3.3 b).)

5 Steelmaking process and casting methods

5.1 Steelmaking

Steelmaking shall be by any process except the air or mixed air and oxygen bottom blown basic conversion process. (See also 3.3 c).)

5.2 Casting method

The steel shall be cast into ingots or continuously cast blooms or billets (see 12.1).

NOTE For the purposes of Table 7 steel 230M07 is supplied as a balanced quality. The other steels listed in Table 12 are supplied as killed free-cutting qualities.

Steels listed in Table 13 are supplied as killed carbon steels.

Steels listed in Table 14 are supplied as killed carbon or killed coarse grain steels depending upon ordered requirements. Steels in Table 15 and Table 16 are classified as low alloy steels.

6 Dimensional tolerances

6.1 Sectional tolerances

6.1.1 Bars shall be supplied to the sectional tolerances given in Table 1 to Table 3.

Table 1 — Tolerances for cold drawn bar

Section	Size, diameter or width across flats	Permitted variation
Round	mm	mm
	$\geq 6 \leq 18$	+ 0 to - 0.070
	$> 18 \leq 30$	+ 0 to - 0.085
	$> 30 \leq 50$	+ 0 to - 0.100
	$> 50 \leq 80$	+ 0 to - 0.120
	$> 80 \leq 100$	+ 0 to - 0.140
Square and hexagon	$\geq 6 \leq 18$	+ 0 to - 0.090
	$> 18 \leq 30$	+ 0 to - 0.110
	$> 30 \leq 50$	+ 0 to - 0.130
	$> 50 \leq 80$	+ 0 to - 0.160
	$> 80 \leq 105$	+ 0 to - 0.250
Flat (width)	< 18	+ 0 to - 0.110
	$> 18 \leq 30$	+ 0 to - 0.130
	$> 30 \leq 50$	+ 0 to - 0.160
	$> 50 \leq 80$	+ 0 to - 0.190
	$> 80 \leq 100$	+ 0 to - 0.220
	$> 100 \leq 130$	+ 0 to - 0.350
	$> 130 \leq 160$	+ 0 to - 1.00
	$> 160 \leq 320$	+ 1.00 to - 1.00
Flat (thickness)	< 18	+ 0 to - 0.110
	$> 18 \leq 30$	+ 0 to - 0.130
	$> 30 \leq 50$	+ 0 to - 0.250
	$> 50 \leq 80$	+ 0 to - 0.350

6.1.2 Thickness shall be measured within 12 mm of the edge for flats.

6.1.3 The diameter of round bars in the as drawn length shall be measured at a distance of at least 150 mm from the end of the bar. Where round bars have been re-cut to an exact length the diameter shall be measured at least 10 mm from the end of the bar.

6.1.4 The cross-sectional measurement of hexagons, squares and flat bars shall be measured at least 25 mm from the end of the bar.

NOTE The very ends of such bars might not necessarily meet the requirements of Table 1 but these should not be regarded as defective if the remainder is in accordance with Table 1.

Table 2 — Tolerances for turned bars

Size, diameter	Permitted variation
mm	mm
$\geq 6 \leq 18$	+ 0 to - 0.070
$> 18 \leq 30$	+ 0 to - 0.085
$> 30 \leq 50$	+ 0 to - 0.100
$> 50 \leq 80$	+ 0 to - 0.120
$> 80 \leq 120$	+ 0 to - 0.140
$> 120 \leq 180$	+ 0 to - 0.160
$> 180 \leq 250$	+ 0 to - 0.185
$> 250 \leq 315$	+ 0 to - 0.210
$> 315 \leq 400$	+ 0 to - 0.230
> 400	+ 0 to - 0.250

6.2 Tolerances for precision ground bars

6.2.1 The appropriate dimensional tolerance class required shall be as selected by the purchaser (see Table 3). Surface texture shall be $0.8 \mu\text{m}$ centre line average maximum ($0.8 \mu\text{m } R_a \text{ max.}$) in accordance with BS 1134-1.

Table 3 — Tolerances for precision ground bars

Section	Size, diameter	Permitted overall variation		
		Class A	Class B	Class C
	mm	mm	mm	mm
Round	$\geq 6 < 75$	0.050	0.025	0.013

6.2.2 Maximum deviation from “out of round” shall be no more than half the ordered diametric tolerance, as measured using a 60° 3-point gauge.

6.2.3 Bars with cold sheared ends shall be measured at a distance from the end not less than the diameter of the bar.

6.3 Straightness tolerance

Drawn and turned bars shall be supplied to the tolerances given in Table 4 and shall be measured as maximum deviation from straightness in any 3 000 mm portion of the bar.

Table 4 — Straightness tolerances

Section	Steel grade	Permitted variation
Rounds	$< 0.25 \%$ carbon	1 in 1 000
	$\geq 0.25 \%$ carbon, alloys and all heat treated grades	1 in 500
Squares and hexagons	$< 0.25 \%$ carbon $\leq 75 \text{ mm}$	1 in 750
	$> 75 \text{ mm}$	1 in 500
Flats	$\geq 0.25 \%$ carbon, alloys and all heat treated grades	1 in 375
	$< 0.25 \%$ carbon	1 in 500
	$\geq 0.25 \%$ carbon, alloys and all heat treated grades	1 in 375

6.4 Special tolerances

The basic specification shall comply with the dimensional tolerances given in Table 1 to Table 4, as appropriate. (See also 3.3 d.)

7 Selection and preparation of test samples

7.1 Selection of test samples

One tensile test and where relevant, one Izod impact test sample, comprising three notches, or three Charpy V-notch impact test samples shall be taken from any batch of the same cast.

For the purpose of subsequent orders, these tests shall be taken as representing all sizes of material from the same cast where the ruling section of the parts does not exceed the ruling section of the test bar already tested.

The samples shall be cut from the heat treated bars or cold finished bars and shall not be further heat treated or mechanically worked after their removal.

7.2 Steel of tensile strength of $1\,225 \text{ N/mm}^2$ or greater

Where the tensile strength of alloy steel is specified as $1\,225 \text{ N/mm}^2$ minimum or greater, the test sample shall be machined to test piece size, plus a grinding allowance if required, before heat treatment.

7.3 Steels for case hardening

7.3.1 Size of test sample

The test sample size shall be 19 mm diameter. (See also 3.3 e.)

7.3.2 Selection of samples

Subject to 7.3.1 one test sample shall be selected to represent each cast. If the size of the test sample is greater than the specified test piece size, test bars shall be prepared by forging and/or machining to that size; but for sizes smaller than 13 mm diameter for carbon and carbon manganese steels and for sizes smaller than 19 mm diameter for alloy steels, the test pieces shall be heat treated in the full section of the sample.

NOTE The properties specified in Table 19 to Table 26 apply only to the preferred test bar sizes and to ruling sections equivalent to these. When components of different ruling sections are carburized and heat treated, different core properties will be obtained. Similarly, it may be necessary to agree mechanical properties when the test sample size is less than the specified test bar size.

Attention is also drawn to the influence of several factors such as steel composition, ruling section and heat treatment, on the hardness of the case. For example, even if a low core strength suffices it will be necessary to use an alloy steel for acceptable case hardenability of the largest section sizes.

7.3.3 Heat treatment of test piece

7.3.3.1 Carbon and carbon manganese steels

The test pieces shall be blank carburized for at least 1 h at the hardening temperature between 900 °C and 930 °C and quenched in oil.

7.3.3.2 Alloy steels

The test pieces shall be blank carburized for at least 1 h at a temperature between 800 °C and 930 °C. After cooling to room temperature they shall be reheated to the single quenching temperature, as given in Table 22, and quenched in oil.

7.4 Location of test pieces for mechanical testing

7.4.1 General

Where longitudinal tests are required, the test piece shall be prepared in accordance with the following:

- a) For ruling sections up to and including 25 mm, the test piece shall be machined coaxially from the test bars.
- b) For ruling sections over 25 mm, the longitudinal axis of the test piece shall be 12.5 mm from the surface of the test bars.
- c) Austenitic stainless steels (see Table 18) supplied as cold drawn bars shall be tested in full section for ruling sections up to and including 19 mm. For ruling sections over 19 mm, the test piece shall be machined coaxially from the test sample.

7.4.2 Transverse and other tests

Where transverse and other tests are required the test piece shall be prepared as specified in the enquiry and/or order. (See also 3.3 f.)

7.5 Frequency of other tests

7.5.1 Number of hardness tests

The manufacturer shall carry out one test per production batch in accordance with the relevant clauses of this Part of BS 970 in order to ensure that the material complies with the specified hardness.

7.5.2 Number of hardenability tests

One test sample selected to represent each cast shall be reduced by forging or rolling to a size not greater than 38 mm diameter which shall represent the full cross section of the material. This test bar shall also be of sufficient size to ensure the complete removal of decarburization in machining to the standard test piece of 25 mm diameter.

8 Test methods and test results

8.1 Tensile test

8.1.1 The tensile test shall be carried out in accordance with BS EN 10002-1.

8.1.2 The specified mechanical properties shall refer to tests taken in the longitudinal direction.

8.1.3 In cases of dispute tensile test pieces shall be machined from bars to the dimensions of the 11.28 mm diameter (100 mm² cross-sectional area) test piece or, if the test sample is too small, to the dimensions of the largest recommended round test piece that can be obtained having a gauge length equal to $5.65\sqrt{S_0}$.

8.1.4 For material not greater than 15 mm diameter or width across flats, unmachined test pieces having a gauge length equal to $5.65\sqrt{S_0}$ shall be used.

8.2 Impact test

The impact properties shall be determined in accordance with BS 131-1. (See also option A.3)

8.3 Hardness test

The Brinell hardness test shall be carried out in accordance with BS 240.

8.4 Hardenability test

Hardenability tests shall be carried out in accordance with the appropriate method of BS 4437.

8.5 Grain size test

Grain size tests shall be carried out in accordance with the appropriate method given in BS 4490. (See also 3.3 g.)

8.6 Intercrystalline corrosion test

If an intercrystalline corrosion test is required it shall be as specified at the time of enquiry and/or order. (See also option A.4)

9 Chemical composition

9.1 Composition ranges

The chemical composition of the steel, based on cast analysis when tested in accordance with BS 6200 shall comply with the appropriate material specifications given in Table 12 to Table 18. (See also 3.3 h), 3.3 i) and option A.5)

NOTE In Table 12 to Table 28 figures in parentheses indicate notes which appear at the end of these tables.

9.2 Residual elements

The maximum limits on residual elements shall be as given in Table 5.

Table 5 — Maximum limits on residual elements

Element	Carbon and carbon manganese grades	Non-austenitic stainless grades	Austenitic stainless grades
	%(m/m)	%(m/m)	%(m/m)
Nickel	0.40	—	—
Chromium	0.30	—	—
Molybdenum	0.15	0.30	1.00
Niobium	—	—	0.20
Titanium	—	—	0.10
Copper	—	0.30	0.70

9.3 Lead bearing steels

The basic specification shall not include lead. (See also option A.5.)

9.4 Product analysis and permitted deviations

NOTE Product analysis may differ from the cast analysis due to heterogeneity arising during casting and solidification. Table 6 shows the deviations from the range specified for cast analysis permitted on product analysis.

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

Test specimens for product analysis shall be taken in accordance with BS 6200-3 or BS Handbook 19.

10 Mechanical properties

NOTE 1 For through hardening steels, the mechanical properties attainable from any steel composition and heat treatment are dependent on the ruling section.

NOTE 2 The requirements in this standard show the limiting ruling section to which the stated mechanical properties apply and the purchaser should select a steel which is specified to give the desired properties in the appropriate ruling section at the time of heat treatment.

NOTE 3 Generally, specified properties are readily achievable even when bulk heat treatment is involved except where noted in Table 19 to Table 28.

NOTE 4 In Table 19 to Table 28 figures in parentheses indicate notes which appear at the end of these tables.

10.1 Tensile properties shall be as given in Table 19 to Table 28 when tested in accordance with BS EN 10002-1.

10.2 Impact properties shall be as given in Table 19 to Table 28 when tested in accordance with BS 131-1.

10.3 Hardness properties shall be as given in Table 19 to Table 28 when tested in accordance with BS 240.

Table 6 — Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element falls	Variation on specified range	
		over max.	under min.
	%(m/m)	%(m/m)	%(m/m)
<i>(a) Carbon, carbon manganese and free cutting steels</i>			
Carbon ^a	≤ 0.25	0.02	0.02
	> 0.25 ≤ 0.50	0.03	0.03
	> 0.50 ≤ 1.05	0.04	0.04
Silicon	≤ 0.40	0.03	0.03
Manganese	≤ 1.00	0.04	0.04
	> 1.00 ≤ 1.50	0.08	0.08
	> 1.50	0.10	0.10
Phosphorus	≤ 0.025	0.005	
	> 0.025 ≤ 0.040	0.006	
	> 0.040 ≤ 0.060	0.008	
Sulfur	≤ 0.025	0.005	
	> 0.025 ≤ 0.040	0.006	
	> 0.040 ≤ 0.060	0.008	
	> 0.060 ≤ 0.10	0.010	
	> 0.10 ≤ 0.20	0.025	0.025
	> 0.20 ≤ 0.40	0.040	0.040
	When range is specified		
	0.015 to 0.040	0.006	0.003
	0.025 to 0.050	0.008	0.005
	0.050 to 0.10	0.010	0.008
Lead	0.15 to 0.35	0.03	0.02