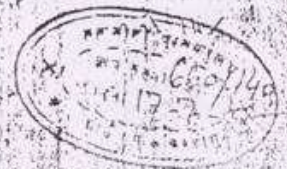


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British Standard Specification for
Wrought steels for mechanical and
allied engineering purposes
Part 1. General inspection and testing procedures
and specific requirements for carbon, carbon manganese
alloy and stainless steels

Norme pour usages mécaniques et industries connexes. Spécifications
générales et caractéristiques particulières
pour aciers au carbone, au carbone-manganèse, alliés et inoxydables
Stähle für mechanische und verwandte technische Zwecke
Allgemeine Überprüfung und Prüfverfahren und besondere Anforderungen
Kohlenstoff- und Kohlenstoff-Mangan-Stähle, legierte und nichtrostende Stähle



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British Standard Specification for
Wrought steels for mechanical and allied engineering purposes

Part 1. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels

Section one. General inspection and testing procedure

1.1 Scope

Section one of this Part of BS 970 specifies the requirements for steelmaking and general testing and inspection procedures for the release of steel in the form of blooms, billets, slabs, bars, rods and forgings, used in the as rolled, as forged, annealed, normalized, bright finished or hardened and tempered condition, as appropriate, and in accordance with the specific requirements for the steels of sections two to five inclusive.

NOTE 1: Forgings above 150 mm ruling section in carbon and alloy steels may be ordered in accordance with BS 28 and BS 4670, respectively, and released to the requirements of those standards.

NOTE 2: The provisions of section one may also be used as a general testing and inspection procedure for wrought steels not included in sections two to five inclusive.

NOTE 3: Particular attention is also drawn to the information given in foreword.

Sections two to five cover specific requirements for the supply of steel as follows:

Section two. Hot rolled and normalized steels, supplied as bright bar and micro-alloyed carbon manganese steels

Section three. Through hardening steels including steels capable of surface hardening by nitriding

Section four. Case hardening steels

Section five. Stainless and heat resisting steels including those supplied as bright bar.

Sizes and tolerances are specified in section six.

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

1.2 Definitions

For the purposes of this Part of BS 970 the definitions given in 1.4.4.1 and 1.13.1 apply.

1.3 Symbols

The symbols used in this standard are given in 1.3.1 to 1.3.4.

1.3.1 Tensile properties (as described in BS 18: Part 2, except for $R_{p0.2}$)

- R_m denotes tensile strength
- R_e denotes yield strength
- A denotes percentage elongation after fracture
- S_0 denotes original cross-sectional area of the gauge length
- $R_{p0.2}$ denotes 0.2% proof stress (non proportional elongation)

- $R_{p1.0}$ denotes 1.0% proof stress (non proportional elongation)
- $R_{t0.5}$ denotes 0.5% proof stress (total elongation)
- $R_{t1.0}$ denotes 1.0% proof stress (total elongation)
- R_{eH} denotes upper yield stress

1.3.2 Impact properties

- KCV denotes Charpy V-notch impact value

1.3.3 Hardness

- HB denotes Brinell hardness
- HV denotes Vickers hardness
- HRC denotes Rockwell hardness (C scale)

1.3.4 Other

- LRS denotes limiting ruling section

1.4 General

1.4.1 Quality. The steel shall be selected and ordered by the purchaser and shall be supplied in accordance with the appropriate general requirements specified in this section and with the specific material requirements specified in sections two to five inclusive (but see also 1.7.1) and with the tolerances specified in section six. The manufacturer shall be responsible to the purchaser with respect to the compliance of the steel with these requirements and any additional requirements specified by the purchaser. All these requirements shall apply equally to steels given in categories 1 and 2.

NOTE: When category 1 and category 2 steels are available, selection should be made from category 1 where possible (see also foreword). To facilitate this selection, category 1 steels are printed throughout the standard in normal (upright) type, and category 2 steels in italic (sloping) type.

1.4.2 Supply options. Where appropriate, the specific requirements of sections two to five cover the following supply options:

- (a) To close limits of chemical composition (A grades) where no mechanical properties or hardenability are specified.

NOTE: For special applications, e.g. in surface hardening, these steels may also be supplied with mechanical properties or hardenability specified by agreement between the purchaser and the supplier.

- (b) To a combination of mechanical properties (M grades) or hardenability requirements (H grades) and chemical composition.

1.4.3 Machinability. Machinability may be improved by higher sulphur content (see 1.7.2.2), by nickel addition (see 1.7.4) or by special heat treatment to promote optimum structure. Where extreme machinability is needed, both sulphur and lead or bismuth additions can be used in conjunction.

NOTE: The presence of titanium may affect on machinability.

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1.4.4 Ruling section and hardenability

1.4.4.1 Definitions

1.4.4.1.1 ruling section. Ruling section is the equivalent diameter of that portion of the product at the time of heat treatment that is most important in relation to mechanical properties.

1.4.4.1.2 limiting ruling section. For any composition of steel, the limiting ruling section is the largest diameter in which certain specified mechanical properties are achieved after a specified heat treatment.

1.4.4.1.3 equivalent diameter. The equivalent diameter of any product, or part of a product, is the diameter at the time of heat treatment of a hypothetical very long bar effectively 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.

NOTE. Further information is given in BS 5046.

1.4.4.2 Mechanical properties

1.4.4.2.1 For through hardening steels, the mechanical properties attainable from any steel composition and heat treatment are dependent on the ruling section. The individual steel specifications of this standard show the limiting ruling section to which the stated mechanical properties apply and the purchaser shall select a steel which is specified to give the desired properties in the appropriate ruling section at the time of heat treatment.

NOTE. Generally, specified properties are readily achievable even when bulk heat treatment is involved. Where appropriate, enhanced properties are quoted which apply to heat treatment of components and die forgings and which may not be achieved by bulk heat treatment. These are clearly identified by a note, e.g. see footnote (13) to table 6.

1.4.4.2.2 For carbon and carbon manganese case-hardening steels, it is customary to test and release steel to specified mechanical property levels using a standard size of test bar. However, because of the effect of section size, the properties are quoted for different test bar sizes in the oil-quenched conditions, i.e. 13 mm, 19 mm and 29 mm, but the 19 mm size shall be used, except by agreement.

1.4.4.2.3 For alloy and boron case-hardening steels, it is now customary to test and release steel to hardenability requirements. Hardenability bands for these steels (based on BS 4437) are included in section four. These hardenability bands may be used as a guide to estimate the tensile strength of a ruling section at the time of heat treatment. When M steels are ordered, the properties quoted are for a test bar size of 19 mm (see 1.133.4.1).

NOTE. The properties specified for both carbon and alloy steels apply only to the test bar size used and the heat treatment specified. If other heat treatments and/or sizes of test bar are used, then different results may be obtained. The conditions for these heat treatments and tests shall be agreed between the purchaser and the supplier.

1.5 Information to be supplied by the purchaser

The following information shall be stated on the enquiry and order. Purchasers should pay particular attention to the fact that the standard permits the options shown in the following list and where no specific choice is made by the purchaser, the supplier may select those considered appropriate, excepting that for items (a), (b), (d), (e),

(f) and (u) he shall refer the matter to the purchaser.

NOTE. A drawing of the part to be made may be useful in appropriate cases.

(a) The steel selected from 2.1, 2.2 or 2.3, section three, section four or section five, or specific requirements for a non-standard steel to be released to the requirements of section one.

(b) The applications of the billets and bars required, e.g. for forging, re-rolling, cold drawing, cold forming, metal coating, induction hardening and welding; the end use, if known, of the material (see 1.9.2); and whether the component is to be nitrided.

(c) Whether the steel is to be supplied to A, M, or H grade requirements (see 1.4.2).

(d) If ordered to the mechanical property requirements of 2.1, the limiting ruling section required for non free cutting steels (see table 2).

If ordered to the requirements of 2.2, the condition, the size and, where appropriate, the tensile strength ranges required (see table 4).

If ordered to the requirements of 2.3, the condition (see table 5).

If ordered to the mechanical property requirements of section three, the ruling section and tensile strength ranges required (see table 6).

If ferritic or martensitic steels are ordered to the mechanical property requirements of section five, the ruling section and tensile strength ranges required (see table 13).

(e) If ordered to the hardenability requirements of sections three or four, the hardness values at the required distances (see 1.15.4 and tables 8, 9 and 10).

(f) In the case of carbon steels supplied to composition only which are not required for forgings and drop forgings, whether rimmed, balanced or killed steel is required (see 1.6.3.1 and appendix B).

(g) If a specific steelmaking or casting process is required or, conversely, is not acceptable (see 1.6.1 and 1.6.2) and, if required, the minimum reduction from the as cast state to the hot worked product (see note to 1.6.2, 1.9.1.2 and 1.18).

(h) If a steel having a controlled grain size is required (see 1.6.4) and the method of measurement if other than method 1 of BS 4490.

(i) The phosphorus and sulphur contents required if different from the standard limits (see 1.7.2).

(j) If a steel containing lead is required (see 1.7.4).

(k) Whether there are special requirements with regard to the amount of residual elements and/or what information is required on the certificate (see 1.7.3 and 1.18).

(l) If any other special quality criteria, e.g. vacuum degassing, ultrasonic testing and cleanliness check, are required (see 1.9).

(m) The condition on delivery in which the material is to be supplied (see 1.10 and tables 7, 12 and 13).

(n) Whether, in the case of billets and bars, the material shall be suitable for cold shearing.

(o) If a maximum decarburization limit is required (see 1.9.2.5).

(p) In the case of austenitic stainless steels, whether an intercrystalline corrosion test is required (see 1.15.6).

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- (j) If a 0.2 % proof stress, and in the case of austenitic steels, and/or a 1.0 % proof stress, is to be determined (see 1.15.1.4).
- (k) If a representative will be sent to witness manufacture and/or testing (see 1.17).
- (l) If a statement giving the cast analysis and/or the results of mechanical or other tests is required (see 1.18).
- (m) If special identification of the steel is required (see 1.19).
- (n) Sizes, lengths and tolerances required (see section six).

1.6 Steelmaking and casting process

1.6.1 General. The steelmaking and casting process shall be at the option of the manufacturer unless otherwise specified on the enquiry and order. The air or mixed air and oxygen bottom blown basic converter process is not permitted.

NOTE. *Electric quality steel* is steel melted in an induction furnace or in a basic lined electric arc furnace. When produced in the electric furnace the conventional double slag process is used. The steel is characterized by a high standard of cleanliness and by low sulphur and phosphorus contents which can also be achieved by various alternative techniques, e.g. by selection of raw materials and/or secondary steelmaking.

Electrically melted steel is steel made in an electric furnace under conditions not necessarily complying with the requirements for electric quality steel and which complies with standards similar to those required of open hearth steel.

1.6.2 Casting process. The steel shall be cast into ingots or shall be continuously cast unless the purchaser specifies a particular method on the enquiry and order.

NOTE. Material in the as cast condition is not covered by this standard. When specifically required, the purchaser may specify a minimum reduction from the as cast state to the hot worked product (see also 1.8.1.2).

1.6.3 Deoxidation

1.6.3.1 Carbon and carbon manganese steels. Carbon and carbon manganese steels supplied as A grades shall be deoxidized as stated in appendix B. If a choice is available, this shall be at the option of the purchaser and shall be stated on the enquiry and order. Steels supplied as M or H grades shall be killed unless otherwise agreed and stated on the order. Steels for case hardening shall be killed. Steels for forgings and drop forgings shall be killed unless otherwise agreed and stated on the order.

1.6.3.2 Boron and micro-alloyed steels. Boron and micro-alloyed steels shall be killed.

1.6.3.3 Alloy and stainless steels. Alloy and stainless steels shall be killed.

1.6.4 Controlled grain size

1.6.4.1 Carbon and carbon manganese steels. If required, many of the steels can be supplied having a controlled grain size of 1 to 5 (coarse grain) or 5 to 8 (fine grain) determined in accordance with the appropriate method of BS 4480.

NOTE 1. Other methods for the determination of grain size may be used by agreement, see also note 1 to 1.6.4.2.

NOTE 2. Where compliance with a specific impact test is required, fine grain steel will normally be supplied.

1.6.4.2 Alloy steels. Alloy steels can be supplied fine grain size controlled, i.e. having a grain size of 5 to 8 determined in accordance with the appropriate method of BS 4480 or another method by agreement. Steels supplied to hardenability requirements are supplied fine-grained and if coarse grain steel is specifically required, then the hardenability

shall be subject to negotiation.

NOTE 1. Steel is normally fine-grained if the total aluminium content is > 0.018 %. However, in cases of dispute the appropriate method of BS 4480 should be used.

NOTE 2. Grain sizes finer than 8 may be permitted by agreement.

NOTE 3. Boron steels are supplied with a grain size of 5 or finer. Micro-alloyed steels are not subject to grain size control.

1.6.5 Cleanliness. If required, standards for the degree of freedom from non-metallic inclusions and methods of determination shall be agreed between the purchaser and the supplier.

1.7 Chemical composition

1.7.1 Composition ranges. The chemical composition of the steel, based on cast analysis, shall comply with the requirements of the appropriate material specification in sections two to five.

NOTE. Where, in exceptional cases, the purchaser requires a steel of other than standard composition, this should be agreed at the time of the enquiry and order.

1.7.2 Sulphur and phosphorus contents

1.7.2.1 Carbon, carbon manganese and boron steels shall be supplied with sulphur and phosphorus contents each of 0.050 % maximum. For alloy steels, the sulphur content shall be 0.040 % maximum and the phosphorus content 0.035 % maximum.

NOTE. Where specifically ordered, a lower content of sulphur and phosphorus, with each element at 0.025 % maximum, may be supplied. This is recommended for certain alloy nitriding steels (see table B) and for tensile strength ranges of 1225 N/mm² minimum and greater. Other limits for sulphur and phosphorus may be agreed between the purchaser and the supplier and stated on the order.

1.7.2.2 Unless otherwise stated in the material specification steels can be supplied to the following controlled sulphur ranges, with associated phosphorus contents, which shall be agreed between purchaser and supplier and stated on the order.

Steels	Sulphur	Phosphorus
	%	%
Carbon and carbon manganese steels, and boron steels unless otherwise specified	0.025–0.050 0.015–0.040	0.050 max. 0.025 max.
Alloy steels	0.025–0.050 0.015–0.040	0.035 max. 0.025 max.

NOTE 1. Other ranges can be supplied by agreement between the purchaser and the supplier.

NOTE 2. These ranges should be used when it is considered desirable to minimize the adverse effect which low sulphur content can have on machinability.

1.7.2.3 The sulphur and phosphorus contents for stainless steels are given in tables 13 and 14.

1.7.3 Residual elements

1.7.3.1 Elements not quoted in the relevant specification shall not be added to the steel without the agreement of the purchaser other than for the purpose of finishing the heat or to achieve anticipated or specified properties.

NOTE. If required, the purchaser, by agreement with the manufacturer, may specify a maximum content of one or more residual elements and/or may require the amount of stated elements to be reported on the appropriate certificate.

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1.7.3.2 In carbon, carbon manganese, boron and alloy steels, percentages of elements up to the following maxima shall be considered as incidental:

- chromium 0.30 %;
- molybdenum 0.15 %;
- nickel 0.40 %.

1.7.3.3 In micro-alloyed steels, maxima for residual elements shall be agreed between the purchaser and the supplier.

1.7.3.4 In stainless steels, percentages of elements up to the following maxima shall be considered as incidental:

Elements	Non-austenitic steels	Austenitic steels
	%	%
Molybdenum	0.30	1.00
Niobium	—	0.20
Titanium	—	0.10
Copper	0.30	0.70

1.7.4 Steels containing lead. Steels containing lead may be supplied by agreement and the agreed lead range shall be stated on the order. In the absence of this agreement it shall be not less than 0.12 % nor greater than 0.25 % on the product analysis and shall be evenly and finely distributed.

NOTE. If requested by the purchaser, the distribution may be checked by either a lead print, lead evaporation test or by ultrasonic methods, the details for which should be agreed between the purchaser and the supplier.

The supplier shall endorse the invoice, delivery document, or appropriate certificate to indicate that lead has been added to comply with the specified requirement, and the steel shall be identifiable by a distinguishing mark agreed between the purchaser and the supplier.

1.8 Product analysis and permitted variations

1.8.1 Analysis of the product may vary from the specified cast analysis due to heterogeneity arising during solidification. Table 1 shows the variations permitted in product analysis in relation to cross sections not greater than 65 000 mm².

The table only applies to fully killed steels and not to rimmed or balanced steels. Except in the case of stainless steels, it does not apply to resulphurized free-cutting steel with respect to the elements sulphur and phosphorus.

The variations 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.

1.8.2 Any product which on subsequent analysis falls outside the permitted variations on the composition range specified for any element, shall be deemed not to comply with the requirements of this standard.

1.8.3 In the event of the results of the analysis of a single sample falling outside the permitted variations on the product analysis, further samples shall be selected for analysis from the remainder of the consignment as follows:

- (a) at least two samples from the same cast for delivered masses up to 5 t;
- (b) at least five samples from the same cast for delivered masses up to 20 t;

(c) at least eight samples from the same cast for delivered masses 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 specified element, the consignment shall be deemed not to comply with the requirements of this standard.

1.8.4 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 British Standard Handbook No. 19.

1.9 Freedom from defects

1.9.1 General

1.9.1.1 Special testing and inspection arrangements may, if required, be agreed between the purchaser and the supplier and should be stated at the time of enquiry and order.

1.9.1.2 The procedures for casting, working, reheating and cooling and the amount of working shall ensure that the product is free from piping, central unsoundness, harmful segregation and other harmful internal and external defects.

1.9.2 Surface defects

1.9.2.1 Products intended for applications such as hot forging and for the production of bright drawn bars which are not required for subsequent overall machining (see 1.9.2.2) shall have a high standard of surface quality and the surface conditioning shall be such as to remove defects detrimental to the appropriate processing and, where specified, the end use.

Products intended for applications such as upset forging, cold heading, cold forging or cold-chamber die casting may require a higher degree of freedom from surface imperfection which shall be agreed between the purchaser and the supplier.

1.9.2.2 Products intended for subsequent overall machining need not have the same freedom from surface defects as specified in 1.9.2.1. Surface conditioning need only be such as to remove harmful defects harmful to the machining allowances.

The machining allowance shall not be less than 2 % on depth on the minimum permissible diameter of rounds or 2 % per side on the minimum permissible dimensions of flats or other solid sections.

NOTE. Machining allowances less than those specified shall be agreed between the purchaser and the supplier.

1.9.2.3 Products for re-rolling or for applications other than those covered by 1.9.2.1 and 1.9.2.2 shall be free from defects harmful to their appropriate processing and, where specified, the end use. Material supplied to these conditions may not be suitable for the applications covered by 1.9.2.1 and 1.9.2.2.

1.9.2.4 Forgings and drop forgings shall be finished in a workmanlike manner and shall be free from flaws and harmful defects.

1.9.2.5 When required, maximum decarburization levels shall be agreed between the purchaser and the supplier.

NOTE. The surfaces of bars for applications where grinding may be required to be free from decarburization. If supplied in the as-forged or bright drawn conditions, overall grinding or turning is permitted to clear decarburization, if necessary.



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Table 1. Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element falls	Variation on specified range		Element	Range in which maximum of specified element falls	Variation on specified range	
		Over max.	Under min.			Over max.	Under min.
(a) Carbon, carbon manganese, boron and micro alloyed steels							
Carbon*	< 0.25 > 0.25 < 0.50* > 0.50 < 1.05	0.02 0.03 0.04	0.02 0.03 0.04	Nickel	< 1.0 > 1.0 < 3.0 > 3.0 < 5.0	0.03 0.05 0.07	0.03 0.05 0.07
Silicon	< 0.40	0.03	0.03	Aluminium	> 0.80 < 1.50	0.10	0.10
Manganese	< 1.0 > 1.0 < 1.5 > 1.5	0.04 0.08 0.10	0.04 0.08 0.10	Vanadium	< 0.30	0.03	0.03
Phosphorus	< 0.025 > 0.025 < 0.040 > 0.040 < 0.060	0.005 0.006 0.008		(c) Stainless and heat resisting steels			
Sulphur	< 0.025 > 0.025 < 0.040 > 0.040 < 0.060 > 0.060 < 0.10 When range is specified: 0.015-0.040 0.025-0.050 0.050-0.10	0.005 0.006 0.008 0.010 0.006 0.008 0.010	0.003 0.005 0.008	Carbon	< 0.03 > 0.03 < 0.25 > 0.25 < 0.50	0.005 0.01 0.02	0.01 0.02
(b) Alloy steels				Silicon	< 1.0 > 1.0 < 2.0	0.05 0.07	0.05 0.07
Carbon	< 0.25 > 0.25 < 0.50 > 0.50	0.01 0.02 0.03	0.01 0.02 0.03	Manganese	< 1.0 > 1.0 < 2.0	0.03 0.04	0.03 0.04
Silicon	< 0.45	0.03	0.03	Phosphorus	< 0.030 > 0.030 < 0.045 > 0.045	0.003 0.004 0.005	
Manganese	< 0.70 > 0.70 < 1.0 > 1.0 < 2.0	0.03 0.04 0.05	0.03 0.04 0.05	Sulphur	< 0.030 > 0.030 < 0.060 Specified range 0.15-0.35	0.003 0.005 0.02	0.02
Phosphorus	< 0.030 > 0.030 < 0.040	0.003 0.004		Chromium	< 10.0 > 10.0 < 15.0 > 15.0 < 20.0 > 20.0	0.10 0.15 0.20 0.25	0.10 0.15 0.20 0.25
Sulphur*	< 0.030 > 0.030 < 0.040 > 0.040 < 0.050 When range is specified: 0.015-0.040 0.025-0.050	0.003 0.004 0.005 0.004 0.005	0.003 0.003	Molybdenum	< 1.0 > 1.0 < 2.0 > 2.0 < 3.0	0.03 0.05 0.08	0.03 0.05 0.08
Chromium	< 0.60 > 0.60 < 1.25 > 1.25 < 2.50 > 2.50 < 4.0	0.03 0.04 0.05 0.10	0.03 0.04 0.05 0.10	Nickel	< 1.0 > 1.0 < 3.0 > 3.0 < 5.0 > 5.0 < 10.0 > 10.0 < 20.0 > 20.0	0.03 0.05 0.07 0.10 0.15 0.20	0.03 0.05 0.07 0.10 0.15 0.20
Molybdenum	< 0.50 > 0.50	0.02 0.03	0.02 0.03	Niobium	All ranges	0.05	0.05
				Selenium	All ranges	0.03	0.03
				Titanium	All ranges	0.05	0.05

* When required by the purchaser and subject to agreement with the supplier, smaller variations for the carbon range over 0.25 % up to including 0.50 % may be agreed.
 * For 606M36, deviations from the sulphur analysis are not specified.

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1.10 Condition of material on delivery

1.10.1 Carbon, carbon manganese, boron, micro-alloyed and alloy steels

1.10.1.1 Blooms, billets, slabs, black bars and rods. Blooms, billets, slabs, black bars and rods shall be supplied as rolled or as forged unless otherwise agreed between purchaser and supplier and stated on the order.

1.10.1.2 Forgings and drop forgings. Forgings and drop forgings shall be supplied in the condition stated on the order.

1.10.1.3 Bright bars. Bright bars shall be supplied in the condition stated on the order.

1.10.1.4 Normalized or hardened and tempered bars. Normalized or hardened and tempered, and normalized or hardened and tempered and subsequently cold drawn bars, shall be supplied to the specified mechanical properties and in the condition stated on the order.

1.10.1.5 Material used in non heat treated condition. Material to be used in the non heat treated condition may be supplied to Brinell hardness values, by agreement between the purchaser and the supplier.

1.10.2 Stainless steels

1.10.2.1 Ferritic steels. Products in ferritic steels shall be supplied in the softened condition. In the case of bright bars, the softening heat treatment may be given before or after any cold sizing, at the option of the manufacturer.

1.10.2.2 Martensitic steels

1.10.2.2.1 Products for subsequent hot working shall be supplied in the softened condition.

1.10.2.2.2 Forgings, drop forgings and bars for machining shall be supplied in the condition stated on the order.

1.10.2.2.3 Bright bars shall be supplied in the hardened and tempered condition, heat treatment being given either before or after any cold sizing, at the option of the manufacturer.

1.10.2.3 Austenitic steels

1.10.2.3.1 Products for subsequent hot working shall normally be supplied in the as forged or as rolled condition.

1.10.2.3.2 Forgings, drop forgings and bars for machining shall be supplied in the softened condition and, if required, subsequently descaled. The softening treatment may be omitted if free cooling of the product from hot working does not lead to the formation of carbide precipitates or sigma or other detrimental phases and if it complies with the requirements for the mechanical and intercrystalline corrosion tests.

1.10.2.3.3 Bright bars shall be supplied in the softened condition, this heat treatment being given before grinding or cold sizing.

1.10.2.3.4 Bars required in the cold drawn condition shall be fully softened before cold drawing.

NOTE. For certain applications it may be necessary to control magnetic properties.

1.11 Heat treatment

The heat treatment to be given to the test bars and to material required in the finally heat-treated condition shall be as specified in tables 3, 7, 12, 13 and 14.

1.12 Mechanical properties

In the material specifications included in this standard, all the specified mechanical properties refer to tests taken in the longitudinal direction (see 1.13.3.3 and 1.13.4.2).

1.13 Selection and preparation of material for mechanical testing (not applicable to micro-alloyed steels*)

1.13.1 Definitions

1.13.1.1 test sample. The portion of the material selected for testing.

1.13.1.2 test bar. The test sample after preparation for heat treatment.

1.13.1.3 test piece. The test sample or test bar as finally prepared for testing.

1.13.2 Tensile strength of 1225 N/mm² or greater. Where the tensile strength of alloy steel is specified as 1225 N/mm² minimum or more, the test bar may be machined to test piece size, plus a grinding allowance if required, before heat treatment. In such cases, the properties obtained are representative of those parts heat treated in the same ruling section as that of the test piece and may not represent larger ruling sections.

1.13.3 Selection and preparation of test bars for tensile and impact tests

1.13.3.1 Material not supplied in the finally heat treated condition. Where the ruling section of the material does not differ appreciably from that of the forging or parts to be produced, test samples may be taken directly from the material and heat treated in the original size. Alternatively, when it is considered either by the purchaser or by the supplier that the results of heat treating in the original size would not be representative of the properties that would be obtained on the forgings or parts to be produced, test samples shall be forged and/or machined to test bars of a diameter, or equivalent diameter, corresponding to the ruling section of the forgings or parts at the time of heat treatment. Test bars shall be given the representative heat treatment for the parts concerned.

Subject to the requirements of 1.4.1, one tensile test and, where relevant, one Izod impact test, comprising three notches, or three Charpy V-notch impact tests shall be taken from any batch of material of similar ruling section from 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 forgings or parts does not exceed the ruling section of the test bar after testing.

1.13.3.2 Bars for machining supplied in the finally heat treated or cold drawn condition. The samples shall be cut from the heat treated bars or cold drawn bars and shall not be further heat treated or mechanically worked after their removal.

Subject to the requirements of 1.4.1, one tensile test and, where relevant, one Izod impact test, comprising three notches, or three Charpy V-notch impact tests shall be made on any batch of bars of similar size from the same cast and heat treated together, when applicable.

*For micro-alloyed steels, the sampling and test procedure shall be by agreement (see 1.2).

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1.13.3.3 *Forgings, drop forgings and machined parts.* For forgings and drop forgings with a ruling section equivalent to a diameter greater than 29 mm, integral test samples may be provided by agreement between the purchaser and the supplier, when a prolongation shall be provided on an agreed proportion of forgings or drop forgings. Unless otherwise agreed, the prolongation shall have a diameter approximately equal to the ruling section of the forging or drop forging at the time of heat treatment and it shall not be finally severed until after heat treatment. Where integral test samples are not practicable or are not required, for small forgings and drop forgings with ruling sections equivalent to a diameter of 29 mm or less, and for parts machined from bars not finally heat treated, separate test samples shall be provided. These shall be provided from the bars or billets from which the forgings, drop forgings or parts are made, or may be additional forgings, drop forgings or parts. The test samples shall be forged and/or machined to test bars of a diameter, or equivalent diameter, corresponding to the ruling section of the forgings, drop forgings or parts and shall be heat treated with the material they represent. The number of tests shall be agreed between the purchaser and the supplier.

Where integral test samples are required and it is not practicable to take tests in a longitudinal direction, tests may be taken in an alternative direction and the properties obtained shall be subject to agreement between the purchaser and the supplier (see 1.13.4.2).

1.13.3.4 *Steels for case hardening*

1.13.3.4.1 *Size of test bar.* The test bar size shall be 19 mm diameter.

NOTE 1: For carbon and carbon manganese steels, 13 mm or 29 mm diameter test bar may be used by agreement (see 1.4.4.2.2).

NOTE 2: For alloy steels with a tensile strength of 1225 N/mm² or greater, see 1.13.2.

1.13.3.4.2 *Selection of samples.* Subject to the requirements of 1.4.1, one test sample shall be selected to represent each cast. If the size of the test sample is greater than the specified test bar size, test bars shall be prepared by forging and/or machining to that size; but for sizes smaller than 13 mm diameter, the test bar shall be heat treated in the full section of the sample.

NOTE: The properties specified in section four apply only to ruling sections equivalent to the preferred test bars. When components of different ruling section are carburized and heat treated, different core properties will be obtained.

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.

1.13.3.4.3 *Heat treatment of test bars*

1.13.3.4.3.1 *Carbon and carbon manganese steels.* The test bars shall be blank carburized for at least 1 h at the hardening temperature given in table 12 (900 °C to 930 °C) and quenched in oil.

1.13.3.4.3.2 *Boron and alloy steels.* The test bars shall be blank carburized for at least 1 h at a temperature between 880 °C and 930 °C. After cooling to room temperature, they shall be reheated to the single quenching temperature, as stated in table 12 and quenched in oil.

1.13.4 *Location of test pieces for mechanical testing*

1.13.4.1 *General.* In the general case 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 pieces shall be 12.5 mm from the surface of the test bars.

(c) Austenitic stainless steels (see section five and table 15) supplied as cold drawn bar 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 bars.

1.13.4.2 *Transverse and other tests.* When transverse tests or tests in other directions are required, the location of the test pieces and values for mechanical properties shall be agreed between the purchaser and the supplier.

1.14 *Frequency of other tests*

1.14.1 *Number of hardness tests.* The manufacturer shall carry out sufficient tests in accordance with the relevant clauses of this standard in order to ensure that the material complies with the specified hardness.

1.14.2 *Number of hardenability tests.* Subject to the requirements of 1.4.1, unless otherwise agreed, 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 carburization in machining to the standard test piece of 25 mm diameter.

1.14.3 *Number of grain size tests.* Subject to the requirements of 1.4.1, when a grain controlled steel is required and unless otherwise agreed, one test sample for the determination of austenitic grain size shall be selected to represent each cast.

1.14.4 *Number of intercrystalline corrosion tests* (applicable to austenitic stainless steels only). If specified and agreed at the time of enquiry and order, one intercrystalline corrosion test shall be carried out per cast per heat treatment batch on the product having the largest equivalent diameter in the batch.

1.15 *Test methods and test results*

1.15.1 *Tensile test*

1.15.1.1 The tensile test shall be carried out in accordance with BS 18: Part 2.

1.15.1.2 In cases of dispute and except as provided in 1.15.1.3, tensile test pieces shall be machined from blooms, billets, slabs, bars, forgings and drop forgings to the dimensions of the 11.28 mm diameter (100 mm² cross-sectional area) test piece or, if the test bar is too small, to the dimensions of the largest recommended round test piece that can be obtained having a gauge length equal to $5.65 \sqrt{S_0}$.

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1.15.1.3 When agreed between the purchaser and the supplier or for material not greater than 15 mm diameter or width across flats, unmachined test pieces having a gauge length equal to $5.65\sqrt{S_0}$ may be used.

1.15.1.4 The properties specified in the relevant material specification or on the order shall be determined and the results obtained shall comply with the requirements.

For the yield strength R_e of non-austenitic steels, the following properties shall be determined for acceptance purposes unless otherwise agreed. Except for steels in the finally cold worked or finally cold worked and ground conditions, either the upper yield stress, R_{eH} , or the 0.5% proof stress (total elongation), $R_{10.5}$, may be determined and the material specification is complied with in this respect if either value satisfies the value of the yield strength R_e . In cases of dispute, the 0.5% proof stress (total elongation), $R_{10.5}$, shall be determined.

For non-austenitic steels in the finally cold worked or finally cold worked and ground conditions, either the upper yield stress, R_{eH} , or the 0.5% proof stress (non-proportional elongation), $R_{p0.5}$, may be determined and the material specification is complied with in this respect if either value complies with the specified yield strength R_e . In cases of dispute, the 0.5% proof stress (non-proportional elongation), $R_{p0.5}$, shall be determined.

When specifically ordered and permitted by the material specification, the 0.2% proof stress (non-proportional elongation), $R_{p0.2}$ of non-austenitic steels shall be measured and the value obtained shall comply with the specified requirement.

For austenitic steels, when specifically ordered the 0.2% proof stress, $R_{p0.2}$, and/or the 1.0% proof stress $R_{p1.0}$, shall be measured and the value obtained shall comply with the specified requirements. The 1% proof stress may only be ordered when permitted by the material specified.

1.15.2 Impact tests. Either one or other of the following tests shall be carried out. The choice shall be the option of the supplier.

(a) Charpy V-notch impact test. This test shall be carried out in accordance with BS 131 : Part 2.

(b) Izod impact test. This test shall be carried out in accordance with BS 131 : Part 1.

The average value of the results obtained for three notches shall comply with the relevant requirements of the material specification. One individual value may be below the specified value, provided it is not less than 70% of that value.

NOTE. It is not possible to convert values from one type of impact test to the other.

In cases of dispute the Izod impact test shall be used.

1.15.3 Hardness test. The Brinell hardness test shall be carried out in accordance with BS 240 : Part 1 using, where possible, a 10 mm diameter ball and load of 3000 kg. Alternatively, Vickers and Rockwell methods of hardness testing in accordance with BS 427 : Part 1 and BS 891 : Part 1, respectively, may be used.

NOTE. Considerable caution should be exercised when converting from one hardness scale to another and in cases of dispute the Brinell hardness test shall be used.

1.15.4 Hardenability test. Hardenability tests shall be carried out in accordance with the appropriate method of BS 4437. The values to be verified shall be selected by the

purchaser in accordance with that standard.

NOTE. Graphs for the comparison of the various H grades are given in appendix A. These are for guidance only.

1.15.5 Grain size test. Grain size tests shall be carried out in accordance with the appropriate method given in BS 4490.

NOTE. Other methods may be used by agreement between the purchaser and the supplier, see 1.6.4.

1.15.6 Intercrystalline corrosion test (applicable to austenitic stainless steels only). A bend test piece shall be prepared and tested in accordance with BS 5903. It shall be sensitized by heating at a temperature of 650 °C for the time specified in table 14 followed by cooling in still air.

1.16 Retests

1.16.1 General. Subject to the requirements of 1.4.1, retests shall be carried out as specified in 1.16.2 to 1.16.6. However, if any test sample or test piece fails to comply with the requirements of 1.15 as a result of incorrect test procedure or faulty equipment, the test results shall be discarded and a further test sample(s) shall be retested in accordance with 1.15.

1.16.2 Tensile tests

1.16.2.1 Should any of the original test pieces fail, twice the original number of test samples shall be selected for retesting, one of which shall be taken from the bar, billet, forging or drop forging from which the original test sample was taken, unless that item has been withdrawn by the manufacturer.

1.16.2.2 The mechanical properties obtained from the test pieces prepared from the further test samples shall comply with the specified requirements. Should any of the retests fail, the material represented shall be deemed not to comply with the requirements of this standard.

1.16.2.3 In the case of material supplied in the heat treated condition, the manufacturer shall have the right to reheat treat the material and resubmit it for testing.

1.16.3 Charpy V-notch impact and Izod impact tests

1.16.3.1 If the average of three impact values is lower than the specified value, or if any one value is lower than 70% of this specified value, three additional test pieces shall be taken from the same sample and tested. The average value of the six tests shall be not less than the specified value. Not more than two individual values may be lower than the specified value and not more than one may be lower than 70% of this value.

1.16.3.2 In the case of material supplied in the heat treated condition, the manufacturer shall have the right to reheat treat the material and resubmit it for testing.

1.16.4 Hardness

1.16.4.1 Should the hardness value determined on any bloom, billet, slab, bar, forging, drop forging or machined part fail to comply with the specified requirements, then an adequate number of items shall be selected for retesting, one of which shall be the original bloom, billet, slab, bar, forging, drop forging or machined part, unless that item has been withdrawn by the manufacturer.

1.16.4.2 Should the hardness results obtained on all the retest items comply with the specified requirements, then the material shall be deemed to comply with this standard.



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1.16.4.3 Should any retest item exhibit hardness values not complying with the specified requirements, then tensile test pieces may be prepared, as applicable, from the items showing the widest deviation, above and/or below the agreed hardness range. Should the results obtained from such tensile test pieces comply with the tensile test requirements of the specification, then the material shall be deemed to comply with this standard.

Failing this, the batch represented by the original tests may be reheat treated and resubmitted for testing.

1.16.5 Hardenability and grain size tests. Should the results of either of these tests fail to comply with the specified requirements and this is confirmed on retesting, the material shall be deemed not to comply with this standard.

1.16.6 Intercrystalline corrosion test. The relevant provisions of BS 5903 shall apply.

1.17 Inspection

The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the order. He shall be at liberty to inspect the manufacture at any stage and to witness the required tests. When the material is to be inspected and tested in the presence of the purchaser's representative, it shall be so stated on the enquiry and order.

1.18 Manufacturer's statement

If required by the order, the manufacturer shall supply a certificate stating the cast analysis of the material, the heat treatment, the results of the mechanical or other tests, or any combinations of these.

The document supplied shall state the steelmaking and casting process and, when requested, the reduction from the as cast state (see 1.6.1 and 1.6.2).

1.19 Marking

If the purchaser requires special marking to be applied to the material then the manner of marking shall be the subject of agreement between the purchaser and the supplier. If this marking is required it shall be stated on the enquiry and order (see also 1.7.4 regarding the marking of lead containing steels).

1.20 Reference symbols for tensile strength ranges of hardened and tempered material

The various tensile strength ranges for the different specifications have been designated with the reference symbols P to Z, as follows.

Reference symbol	Tensile strength*
	N/mm ² *
P	550-700
Q	625-775
R	700-850
S	775-925
T	850-1000
U	925-1075
V	1000-1150
W	1075-1225
X	1150-1300
Y	1225-1375
Z	1550 min.

*1 N/mm² = 1 MPa.

NOTE 1. Other mechanical properties associated with these ranges are detailed in sections two to five.

NOTE 2. These values for the tensile ranges closely approximate to those used in the previous edition of this standard. In the case of the minimum values, the maximum positive and negative deviation from the values previously specified in tonf/in² is +1.75 % (P range) -0.65 % (Y range) and the maximum positive and negative deviations from the values previously specified in N/mm² (BS 970 Part 6) is +0.81 % (Q range) -1.21 % (Y range).

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1.16.4.3 Should any retest item exhibit hardness values not complying with the specified requirements, then tensile test pieces may be prepared, as applicable, from the items showing the widest deviation, above and/or below the agreed hardness range. Should the results obtained from such tensile test pieces comply with the tensile test requirements of the specification, then the material shall be deemed to comply with this standard.

Failing this, the batch represented by the original tests may be reheat treated and resubmitted for testing.

1.16.5 Hardenability and grain size tests. Should the results of either of these tests fail to comply with the specified requirements and this is confirmed on retesting, the material shall be deemed not to comply with this standard.

1.16.6 Inter-crystalline corrosion test. The relevant provisions of BS 5903 shall apply.

1.17 Inspection

The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the order. He shall be at liberty to inspect the manufacture at any stage and to witness the required tests. When the material is to be inspected and tested in the presence of the purchaser's representative, it shall be so stated on the enquiry and order.

1.18 Manufacturer's statement

If required by the order, the manufacturer shall supply a certificate stating the cast analysis of the material, the heat treatment, the results of the mechanical or other tests, or any combinations of these.

The document supplied shall state the steelmaking and casting process and, when requested, the reduction from the as cast state (see 1.6.1 and 1.6.2).

1.19 Marking

If the purchaser requires special marking to be applied to the material then the manner of marking shall be the subject of agreement between the purchaser and the supplier. If this marking is required it shall be stated on the enquiry and order (see also 1.7.4 regarding the marking of lead containing steels).

1.20 Reference symbols for tensile strength ranges of hardened and tempered material

The various tensile strength ranges for the different specifications have been designated with the reference symbols P to Z, as follows.

Reference symbol	Tensile strength
	N/mm ² *
P	550-700
Q	625-775
R	700-850
S	775-925
T	850-1000
U	925-1075
V	1000-1150
W	1075-1225
X	1150-1300
Y	1225-1375
Z	1550 min.

*1 N/mm² = 1 MPa.

NOTE 1. Other mechanical properties associated with these ranges are detailed in sections two to five.

NOTE 2. These values for the tensile ranges closely approximate to those used in the previous edition of this standard. In the case of the minimum values, the maximum positive and negative deviation from the values previously specified in tonf/in² is +1.75% (P range), -0.85% (Y range) and the maximum positive and negative deviations from the values previously specified in N/mm² (BS 970 : Part 6) is +0.81% (Q range) -1.21% (Y range).

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Table 2. Hot rolled and normalized steels:
 chemical composition and mechanical property requirements
 (for requirements for through hardening steels capable of surface hardening by nitriding, see section three)

Steel	Carbon composition	C	Mn	Others	L&S	F _u min	F _y min	K _{CV} min	Impact (J)	Impact (ft-lb)	KCV min	100-1824
Carbon steels (as rolled)												
040A04	0.08 max	0.30-0.50										121 min
040A10	0.08-0.13	0.30-0.50										
040A12	0.10-0.15	0.30-0.50										
080A15	0.13-0.18	0.70-0.90										
080A20	0.18-0.23	0.70-0.90										
080A25	0.20 max	0.80 max										
Carbon steels (normalized)												
080M15	0.11-0.19	0.60-1.00			63	350	175	22				109-1824
080M15	0.16-0.24	0.50-0.90			150	400	215	21				126-1724
070M20	0.22-0.30	0.50-0.90			250	400	200	20				143-1924
070M26	0.26-0.34	0.60-1.00			63	480	245	20				126-1724
080M30	0.32-0.40	0.60-1.00			150	480	230	19				143-1924
080M36	0.36-0.44	0.60-1.00			63	550	245	16				134-1824
080M40	0.42-0.50	0.60-1.00			190	550	280	17				152-2074
080M46	0.45-0.55	0.60-1.00			250	620	310	14				179-2284
080M40	0.50-0.60	0.50-0.90			63	620	280	15				179-2284
					190	620	310	14				163-2144
					250	570	295	14				201-2554
					63	600	310	13				170-2234
Carbon steels (as rolled and softened)												
060A62	0.60-0.85	0.50-0.70										207 max
060A62	0.65-0.70	0.50-0.70										217 max
060A67	0.65-0.70	0.70-0.90										229 max
060A67	0.70-0.75	0.50-0.70										241 max
060A72	0.75-0.82	0.50-0.70										255 max
090A78	0.78-0.85	0.50-0.70										269 max

* Symbols in parentheses indicate values which appear at the end of the table

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Table 2. Hot rolled and normalized steels:
 chemical composition and mechanical property requirements (continued)

Steel	Chemical composition				LRS	R _m min	R _{p0.2} min	R _{p0.01} min	Impact 11b	KCV max
	Category 211	C	Mn	Pb max						
Carbon manganese steels (normalized)										
120M19	120M19	0.15-0.23	1.00-1.40	mm	500	265	20	25	28	173-192.4
120M28	120M28	0.24-0.32	1.00-1.40	100	460	265	19	25	28	224-183.4
120M36	120M36	0.32-0.40	1.00-1.40	250	450	275	16	25	28	152-207.4
150M19	150M19	0.15-0.23	1.30-1.70	150	530	310	17	38	35	149-207.4
150M28	150M28	0.24-0.32	1.30-1.70	150	590	355	16	38	35	173-223.4
150M36	150M36	0.32-0.40	1.30-1.70	250	510	385	17	38	35	152-207.4
170M19	170M19	0.15-0.23	1.30-1.70	150	550	355	16	25	28	146-197.4
170M28	170M28	0.24-0.32	1.30-1.70	150	600	375	16	25	28	173-223.4
170M36	170M36	0.32-0.40	1.30-1.70	250	560	400	14	25	28	159-229.4
190M19	190M19	0.15-0.23	1.30-1.70	150	620	385	15	25	28	170-223.4
190M28	190M28	0.24-0.32	1.30-1.70	250	600	355	15	25	28	159-229.4
190M36	190M36	0.32-0.40	1.30-1.70	250	600	355	15	25	28	170-223.4
230M07	230M07	0.15 max	0.90-1.30	100	160	215	22	22	22	103 mm
230M07	230M07	0.15 max	0.90-1.30	100	160	215	22	22	22	103 mm

11) See Note 14.1
 12) R_{p0.01} min > 1 MPa
 * applicable if fine grain controlled material is delivered
 * where only
 * minimum silicon content can be agreed between
 * purchaser and supplier
 * for example
 * 0.015-0.035
 * 0.010 max 0.035
 * 0.010 max 0.035

Table 3. Normalizing requirements (also applicable to the steels specified in 2.2)

Steels		Normalizing temperature °C
Category 1 (1)	Category 2 (1)	
080M15		890-920
070M20		880-910
070M26		870-900
080M30		860-890
080M36		840-870
080M40		830-860
080M46		820-850
080M50		810-840
070M55		810-840
	120M19	850-900
	120M28	850-880
120M36		840-870
150M19		860-900
	150M28	850-880
150M36		840-870
220M07		900-930
230M07		900-930

(1) See note to 1.4.1.

2.2 Specific requirements for steels supplied as bright bar (for requirements for stainless and heat-resisting steels supplied as bright bar, see section five)

This subclause specifies requirements for steels supplied in the bright condition, excluding those for bright stainless

steels (see section five) and also separates them from other conditions of the steels which will be found in 2.1 and section three. It applies to bars supplied in the cold drawn, turned and ground conditions. Precision ground bars include bars supplied in the drawn and ground, and turned and ground conditions. These finishes follow hot rolling and various thermal treatments giving a wide range of mechanical properties. Drawn bars are also available in the finally thermally treated condition.

Bright steel bars are processed from the hot worked condition to achieve an oxide-free surface with greater dimensional accuracy. In addition, cold drawing has an effect on the mechanical properties and may also improve the machinability of the material, these effects being most significant with low carbon steels. Turning and grinding reduces or removes decarburization and surface irregularities associated with the hot worked bar.

The requirements specified in table 4 are for the category steels in 2.1 and section three. Table 4 covers the range of chemical analyses and mechanical properties normally required from steels in the bright condition. They are the most commonly used steels and therefore should be more readily available in small quantities and from stockholding sources.

It should be appreciated that a wider range of other specifications is also available in the bright condition, including the case hardening steels (section four) and the category 2 steels of section three.

Tolerances for the various finishes available are given in tables 20, 21 and 22 in section six.

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Table 4. Steels supplied as bright bar : chemical composition and mechanical property requirements

Steel (1)	Chemical composition				Condition (2)	Size (3) (diameters or section sizes)	P _{0.2} min (N/mm ²)	P _{0.2} max (N/mm ²)	A ₅₀ min (%)	Impact (J/cm ²)	J ₁₀ min (N/mm ²)	J ₁₀ max (N/mm ²)
	C	Mn	Cr	Others								
Carbon steels												
	%	%	%	%								
080M15	0.12-0.18	0.60-1.00			Normalized + turned or ground Hot rolled + cold drawn or hot rolled + cold drawn + ground	6 ≤ 63 > 63 ≤ 150	175 165	22 22				109-163a 101-152a
												126-173a 116-170a
070M20	0.16-0.24	0.50-0.90			Normalized + turned or ground Hot rolled + cold drawn or hot rolled + cold drawn + ground	6 ≤ 150 > 150 ≤ 250	215 200	21				420 390 370 280 280
												143-192a 126-179a
070M26	0.22-0.30	0.50-0.90			Normalized + turned or ground Hot rolled + cold drawn or hot rolled + cold drawn + ground	6 ≤ 63 > 63 ≤ 250	245 215	20				440 420 400 330 310
												143-192a 134-183a
					Normalized + turned or ground Hot rolled + cold drawn or hot rolled + cold drawn + ground	6 ≤ 150 > 150 ≤ 250	245 230	19				460 440 420 345 320
												152-207 175-229
					Normalized + turned or ground Hot rolled + cold drawn or hot rolled + cold drawn + ground	6 ≤ 63 > 63 ≤ 70	340 340	18 16				310 300
												152-207 175-229
					Hardness and tempered or cold drawn or hardened and tempered + cold drawn + ground	6 ≤ 19 > 6 ≤ 19	625-775 625-775	13 12				340 430

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Figures in parentheses indicate notes which appear at the end of the table

Table 4. Steels supplied as bright bar:
chemical composition and mechanical property requirements (continued)

Steel (7)	Chemical composition				Condition (9)	Size (8) (diameter or thickness)	R _m	R _{p0.2}	A ₅ min on 5.65Z ₁₅	Impact (used mm) KCV/min	R _{cu} (10) min	HB	
	C	Mn	P	S									
Carbon steels													
080M40	0.36-0.44	0.60-1.00			Normalized + turned or ground	≥ 6 ≤ 150 ≥ 150 ≤ 750	N/mm ² 550 min 510 min	280 245	16 17	15 16	J	N/mm ² (2)	152-207a 146-191a
080M50	0.45-0.55	0.60-1.00			Hardened and tempered + turned or ground	≥ 6 ≤ 63 ≥ 63 ≤ 19	N/mm ² 625-775 700-850	385 465	16 17	25 25	28 28	355 450	179-219 201-255
080M50	0.45-0.55	0.60-1.00			Normalized + turned or ground	≥ 6 ≤ 150 ≥ 150 ≤ 750	N/mm ² 670 min 510 min	310 295	14 14	-	-	-	179-229a 183-211a
080M50	0.45-0.55	0.60-1.00			Hardened and tempered + turned or ground	≥ 6 ≤ 150 ≥ 63 ≤ 700	N/mm ² 675-775 700-850	390 430	15 14	-	-	-	179-219 201-255
080M50	0.45-0.55	0.60-1.00			Turned, ground or cold drawn and finally softened	-	-	-	-	-	-	187 max	

Figures in parentheses indicate notes which appear at the end of the table.

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Table 4. Steels supplied as bright bar:
chemical composition and mechanical property requirements (continued)

Steel (7)	Chemical composition				Condition (8)	Size (9) (Diameter or section flat)	R _m N/mm ² (10)	A ₅ min 0.565L ₀	Impact Total min. kJ/cm ²	R _{ap} 210 min	HB
	C	Mn	Cu	Ni							
070M55	%	%	%	%	Normalized + turned or ground	mm > 6 ≤ 63 > 63 ≤ 250	N/mm ² (10) 355 310	12 13	J	N/mm ² (12)	201-255 (at 170-210 (at
	%	%	%	%							
070M55	%	%	%	%	Normalized + cold drawn or normalized + cold drawn + ground	mm > 6 ≤ 13 > 13 ≤ 16 > 16 ≤ 40 > 40 ≤ 63 > 63 ≤ 78	N/mm ² (10) 510 495 440 420	7 7 8 9	-	-	570 495 440 420
	%	%	%	%							
070M55	%	%	%	%	Hardened and tempered + turned or ground	mm > 6 ≤ 100 > 100 ≤ 1000	N/mm ² (10) 415 480 570	14 14 12	-	-	301-355 248-307 555
	%	%	%	%							
070M55	%	%	%	%	Hardened and tempered + cold drawn or normalized + cold drawn + ground	mm > 29 ≤ 100 > 100 ≤ 1000	N/mm ² (10) 475 510 525 595	10 10 10 9	-	-	201-255 (at 273-277 (at 485 560
	%	%	%	%							
070M55	%	%	%	%	Turned, ground or cold drawn and finally softened	-	-	-	-	-	201 max
	%	%	%	%							
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Normalized + turned or ground	mm > 6 ≤ 150 > 150 ≤ 250	N/mm ² (10) 355 340	15 16	-	-	174-223 (at 163-211 (at
	1.00M36 0.12-0.40 1.00-1.40										
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Hot rolled + cold drawn or hot rolled + cold drawn + ground	mm > 6 ≤ 13 > 13 ≤ 16 > 16 ≤ 40 > 40 ≤ 63 > 63 ≤ 76	N/mm ² (10) 565 555 525 510 480	6 7 8 9 9	-	-	530 510 460 400 380
	1.00M36 0.12-0.40 1.00-1.40										
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Hardened and tempered + turned or ground	mm > 6 ≤ 100 > 100 ≤ 1000	N/mm ² (10) 415 510 570	18 16 14	-	-	385 480 555 223-277
	1.00M36 0.12-0.40 1.00-1.40										
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Hardened and tempered + cold drawn or normalized + cold drawn + ground	mm > 29 ≤ 100 > 100 ≤ 1000	N/mm ² (10) 475 510 525 595	10 10 10 9	-	-	178-223 301-355 223-277
	1.00M36 0.12-0.40 1.00-1.40										
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Normalized + turned or ground	mm > 6 ≤ 150 > 150 ≤ 250	N/mm ² (10) 325 295	18 17	-	-	152-202 (at 146-197 (at
	1.00M36 0.12-0.40 1.00-1.40										
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Hardened and tempered + turned or ground	mm > 13 ≤ 150 > 150 ≤ 250	N/mm ² (10) 340 430 510	18 16 16	-	-	152-207 178-229 201-255
	1.00M36 0.12-0.40 1.00-1.40										
Carbon manganese steels	1.00M36 0.12-0.40 1.00-1.40				Hardened and tempered + cold drawn or normalized + cold drawn + ground	mm > 6 ≤ 150 > 150 ≤ 250	N/mm ² (10) 360 450 520	13 12 10	-	-	345 435 510 201-255 (at
	1.00M36 0.12-0.40 1.00-1.40										

Figures in parentheses indicate notes which appear at the end of the table.

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