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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

Aciers corroyés pour usages mécaniques et industriels connexes. Spécifications
Partie 1. Contrôle général, méthodes d'essai et caractéristiques particulières des aciers au carbone, au carbone-manganèse, alliés et inoxydables

Schmiedstähle für mechanische und verwandte technische Zwecke
Teil 1. Allgemeine Überprüfung und Prüfverfahren und besondere Anforderungen an Kohlenstoff- und Kohlenstoff-Mangan-Stähle, legierte und nichtrostende Stähle

British Standards Institution

Contents

Foreword

This Part of this British Standard has been prepared under the direction of the Iron and Steel Standards Committee. It forms Part 1 of a restructured and metricated BS 970 and is a revision of Parts 1 to 4 of BS 970 published between 1970 and 1972, excluding the valve steels specifications which will be dealt with separately. Parts 1 to 3 of BS 970, published between 1970 and 1972, and Supplement No. 1 (1973) to BS 970 : Part 3 : 1971 are now withdrawn. BS 970 : Part 4 : 1970 is altered by amendment to withdraw the requirements superseded by this standard.

This Part is restructured as follows:

Section one. General inspection and testing procedure;

Section two. Specific requirements for hot rolled and normalized steels, for steels supplied as bright bar and for micro-alloyed carbon manganese steels;

Section three. Specific requirements for through hardening steels including steels capable of surface hardening by nitriding;

Section four. Specific requirements for case hardening steels;

Section five. Specific requirements for stainless and heat resisting steels including those supplied as bright bar;

Section six. Specific requirements for sizes and tolerances.

Thus, four separate Parts and a supplement of the previous edition of BS 970 have been combined into one publication and the information is presented in a more concise tabular form. The standard has also been restructured so that each section contains all the steels intended for a particular purpose or which have other features in common. For example, section four contains all the case hardening steels, whether carbon or alloy.

The provisions for valve steel covered by BS 970 : Part 4 : 1970 and the provisions for steels for hot formed and heat-treated springs covered by BS 970 : Part 5 : 1972 will be separately revised.

The procedure defined in section one of this Part is primarily for use in conjunction with the related material specifications given in the other sections of the standard. However, section one also provides a general testing and inspection procedure for wrought steels to which reference can be made in the absence of other agreed requirements.

This Part of the standard applies to material in the following wrought forms in carbon, carbon manganese, alloy, stainless and heat resisting steels:

(a) blooms;
(b) billets;
(c) slabs;
(d) bars;
(e) rods;
(f) forgings.

These forms are subsequently referred to in this standard as the product. This term does not apply to wire, which is covered by other British Standards.

Some steels included in Parts 1 to 4 of BS 970 published between 1970 and 1972 have been omitted and others have been added. These changes are summarized in appendix D. In deciding the steels to be included in the revision (see sections two to five) particular attention was paid to reducing the number of steels specified compared with the editions published between 1970 and 1972. This task was made more complicated because of the need to introduce boron containing steels, micro-alloyed steels and other steels worthy of inclusion. Whilst it was recognized that the previous editions contained too many steels, it was also considered that in many cases steels could not be eliminated quickly because their usage was well established and for critical parts changes would need to be validated. It was therefore decided that the only realistic way to promote a reduction in the number of steels would be by dividing the specific requirements for the steels into TWO CATEGORIES. Category 1 steels are a rationalized series for use in new designs, and in established designs whenever possible. No compulsion is intended for the use of category 1 steels but it is anticipated that responsible designers and purchasing agents will appreciate the significant advantages to be gained from rationalization and will therefore concentrate on the use of this list. Appendix C has been included to assist the selection of through hardening steels.

In accordance with international trends, but with the exception of section five, Charpy V-notch impact values are specified, in addition to the previously specified Izod values. In this edition of the standard, either form of test is permitted but in cases of dispute the Izod values are to be used. However, consideration may be given in future to the deletion of Izod values.

The opportunity has also been taken to rationalize the values for tensile ranges expressed in SI units so that they advance in equal steps (see **1.20**). Thus, having obtained a 'fix' on any one range it is relatively easy to deduce the values for the other ranges. The changes in minima from those used in the editions published between 1970 and 1972 do not exceed +1.75 % or −1.21 %.

Generally, mechanical properties specified for M steels are achievable with any reasonably effective heat treatment facility, including that for bulk heat treatment of bars or rods. There is, however, widespread experience clearly demonstrating that enhanced mechanical properties are readily achieved when treating components and die forgings. This is pertinent in the higher tensile ranges where it is normal practice to machine bars in the softened condition prior to hardening. In those instances where the specified properties may not be achievable with bulk heat treatment, an appropriate note is appended.

An explanation of the designation system used in this standard, together with a two-way index of the current designation system and that used in the now obsolete 1955 edition, is given in PD 6474. Appendix D to this Part of this standard, in addition to serving as an index, also provides a comparison between the steels now included and those in the editions published between 1970 and 1972 and the 1955 edition.

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

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 29 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_e)

R_m	denotes tensile strength
R_e	denotes yield strength
A	denotes percentage elongation after fracture
S_o	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 note to **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 whenever 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 supply options as follows.

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

NOTE. For special applications, e.g. induction 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 is enhanced by higher sulphur content (see **1.7.2.2**), by a lead addition (see **1.7.4**) or by special heat treatment to promote optimum structure. Where extremely high machinability is needed, both sulphur and lead or other elements can be used in conjunction.

NOTE. The presence of titanium may have an adverse effect on

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 **1.13.3.4.1**).

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), (c), (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 cleanness 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**).

(q) 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**).

(r) If a representative will be sent to witness manufacture and/or testing (see **1.17**).

(s) If a statement giving the cast analysis and/or the results of mechanical or other tests is required (see **1.18**).

(t) If special identification of the steel is required (see **1.19**).

(u) 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 arc furnace the conventional double slag process is used. The steel is characterized by a high standard of cleanness 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 **1.9.1.2**).

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 4490.

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 4490 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 4490 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 Cleanness. 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 6) 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.

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 exudation 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 mm^2.

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 extrusion 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 having regard to the machining allowance.

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 these may be agreed between the purchaser and the supplier.

1.9.2.3 Products for rerolling 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 induction hardening may be required to be free from decarburization and they will usually be turned or ground. If supplied in either the black or bright drawn conditions, overall grinding or turning may be permitted to clear decarburization, if necessary.

Table 1. 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.
	%	%	%
(a) *Carbon, carbon manganese, boron and micro-alloyed steels*			
Carbon*	⩽ 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	⩽ 1.0	0.04	0.04
	> 1.0 ⩽ 1.5	0.08	0.08
	> 1.5	0.10	0.10
Phosphorus	⩽ 0.025	0.005	
	> 0.025 ⩽ 0.040	0.006	
	> 0.040 ⩽ 0.060	0.008	
Sulphur	⩽ 0.025	0.005	
	> 0.025 ⩽ 0.040	0.006	
	> 0.040 ⩽ 0.060	0.008	
	> 0.060 ⩽ 0.10	0.010	
	When range is specified:		
	0.015–0.040	0.006	0.003
	0.025–0.050	0.008	0.005
	0.050–0.10	0.010	0.008
(b) *Alloy steels*			
Carbon	⩽ 0.25	0.01	0.01
	> 0.25 ⩽ 0.50	0.02	0.02
	> 0.50	0.03	0.03
Silicon	⩽ 0.45	0.03	0.03
Manganese	⩽ 0.70	0.03	0.03
	> 0.70 ⩽ 1.0	0.04	0.04
	> 1.0 ⩽ 2.0	0.05	0.05
Phosphorus	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.040	0.004	
Sulphur* †	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.040	0.004	
	> 0.040 ⩽ 0.050	0.005	
	When range is specified:		
	0.015–0.040	0.004	0.003
	0.025–0.050	0.005	0.003
Chromium	⩽ 0.60	0.03	0.03
	> 0.60 ⩽ 1.25	0.04	0.04
	> 1.25 ⩽ 2.50	0.05	0.05
	> 2.50 ⩽ 4.0	0.10	0.10
Molybdenum	⩽ 0.50	0.02	0.02
	> 0.50	0.03	0.03
Nickel	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 3.0	0.05	0.05
	> 3.0 ⩽ 5.0	0.07	0.07
Aluminium	> 0.80 ⩽ 1.50	0.10	0.10
Vanadium	⩽ 0.30	0.03	0.03
(c) *Stainless and heat resisting steels*			
Carbon	⩽ 0.03	0.005	
	> 0.03 ⩽ 0.25	0.01	0.01
	> 0.25 ⩽ 0.50	0.02	0.02
Silicon	⩽ 1.0	0.05	0.05
	> 1.0 ⩽ 2.0	0.07	0.07
Manganese	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 2.0	0.04	0.04
Phosphorus	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.045	0.004	
	> 0.045	0.005	
Sulphur	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.080	0.005	
	Specified range		
	0.15–0.35	0.02	0.02
Chromium	⩽ 10.0	0.10	0.10
	> 10.0 ⩽ 15.0	0.15	0.15
	> 15.0 ⩽ 20.0	0.20	0.20
	> 20.0	0.25	0.25
Molybdenum	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 2.0	0.05	0.05
	> 2.0 ⩽ 3.0	0.08	0.08
Nickel	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 3.0	0.05	0.05
	> 3.0 ⩽ 5.0	0.07	0.07
	> 5.0 ⩽ 10.0	0.10	0.10
	> 10.0 ⩽ 20.0	0.15	0.15
	> 20.0	0.20	0.20
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 and including 0.50 % may be agreed.

†For 606M36, deviations from the sulphur analysis are not specified.

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/mm^2 or greater. Where the tensile strength of alloy steel is specified as 1225 N/mm^2 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 already tested.

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 **2.3**).

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/mm^2 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 mm^2 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 $5.65\sqrt{S_o}$.

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 $5.65\sqrt{S_o}$ 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), $R_{t0.5}$, 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), $R_{t0.5}$, 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 of the 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 test

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 specification requirements, then the batch shall be deemed to comply with this standard.

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/mm^2 = 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 $tonf/in^2$ is +1.75 % (P range) −0.85 % (Y range) and the maximum positive and negative deviations from the values previously specified in N/mm^2 (BS 970 : Part 6) is +0.81 % (Q range) −1.21 % (Y range).

Section two. Specific requirements for hot rolled and normalized steels, for steels supplied as bright bar and for micro-alloyed carbon manganese steels

2.1 Specific requirements for hot rolled and normalized steels (for requirements for through hardening steels including steels capable of surface hardening by nitriding, see section three)

This subsection brings together all the steels used in the hot rolled and normalized conditions and also separates them from other conditions of these carbon and carbon manganese steels which will be found in **2.2** and section three. Additionally, as with other sections, the steels in this section have been divided into two categories. Category 1 steels should be used for new designs and for established designs whenever possible.

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

(for requirements for through hardening steels including steels capable of surface hardening by nitriding, see section three)

Steel		Chemical composition			LRS	R_m min.	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact (3)		HB
Category 1 (1)	Category 2 (1)	C	Mn	Others	$\varnothing$	σ_B	σ_T	δ	Izod min.	KCV min.	
Carbon steels (as rolled)											
		%	%	%	mm	N/mm² (2)	N/mm² (2)		ft·lb	J	
040A04		0.08 max.	0.30–0.50								
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								
055M15		0.20 max.	0.80 max.		–	–	–	–	–	–	121 min.
Carbon steels (normalized)											
080M15		0.11–0.19	0.60–1.00		63	350	175	22	–	–	109–163 (4)
					150	330	165	22	–	–	101–152 (4)
070M20		0.16–0.24	0.50–0.90		150	430	215	21	–	–	126–179 (4)
					250	400	200	21	–	–	116–170 (4)
070M26		0.22–0.30	0.50–0.90		63	490	245	20	–	–	143–192 (4)
					250	430	215	20	–	–	126–179 (4)
080M30		0.26–0.34	0.60–1.00		150	490	245	20	–	–	143–192 (4)
					250	460	230	19	–	–	134–183 (4)
080M36		0.32–0.40	0.60–1.00		63	550	280	16	20	22	152–207 (4)
					250	490	245	18	–	–	143–192 (4)
080M40		0.36–0.44	0.60–1.00		150	550	280	16	15	16	152–207 (4)
					250	510	245	17	–	–	146–197 (4)
080M46		0.42–0.50	0.60–1.00		63	620	310	14	–	–	179–229 (4)
					250	550	280	15	–	–	152–207 (4)
080M50		0.45–0.55	0.60–1.00		150	620	310	14	–	–	179–229 (4)
					250	570	295	14	–	–	163–217 (4)
070M55		0.50–0.60	0.50–0.90		63	700	355	12	–	–	201–255 (4)
					250	600	310	13	–	–	170–223 (4)
Carbon steels (as rolled and softened)											
060A62		0.60–0.65	0.50–0.70								207 max.
060A67		0.65–0.70	0.50–0.70								217 max.
080A67		0.65–0.70	0.70–0.90								229 max.
060A72		0.70–0.75	0.50–0.70								241 max.
060A78		0.75–0.82	0.50–0.70								255 max.
060A81		0.78–0.85	0.50–0.70								269 max.

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

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

Steel		Chemical composition			LRS	R_m min.	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact (3)		HB
Category 1 (1)	Category 2 (1)	C	Mn	Others					Izod min.	KCV min.	
Carbon manganese steels (normalized)											
		%	%	%	mm	N/mm² (2)	N/mm² (2)		ft lb	J	
	120M19	*0.15–0.23*	*1.00–1.40*		*100*	*500*	*295*	*20*	*25*	*28*	*143–192 (4)*
					250	*460*	*265*	*19*	–	–	*134–183 (4)*
	120M28	*0.24–0.32*	*1.00–1.40*		*150*	*550*	*325*	*16*	*25*	*28*	*152–207 (4)*
					250	*530*	*310*	*17*	–	–	*149–201 (4)*
120M36		0.32–0.40	1.00–1.40		150	590	355	15	–	–	174–223 (4)
					250	570	340	16	–	–	163–217 (4)
150M19		0.15–0.23	1.30–1.70		150	550	325	18	30	35	152–207 (4)
					250	510	295	17	–	–	146–197 (4)
	150M28	*0.24–0.32*	*1.30–1.70*		*150*	*590*	*355*	*16*	*25*	*28*	*174–223 (4)*
					250	*560*	*325*	*16*	–	–	*159–212 (4)*
150M36		0.32–0.40	1.30–1.70		150	620	385	14	–	–	179–229 (4)
					250	600	355	15	–	–	170–223 (4)
Carbon free cutting steels (as rolled or normalized)											
220M07		0.15 max.	0.90–1.30	Si (5) S 0.20–0.30 P 0.070 max. (6)	100	360	215	22	–	–	103 min.
230M07		0.15 max.	0.90–1.30	Si (5) S 0.25–0.35 P 0.070 max. (6)	100	360	215	22	–	–	103 min.

(1) See note to **1.4.1**.
(2) 1 N/mm² = 1 MPa.
(3) Only applicable if fine grain controlled material is ordered.
(4) For guidance only.
(5) A maximum silicon content can be agreed between the purchaser and the supplier.
(6) Higher phosphorus contents or ranges, for example 0.040 % to 0.090 % or 0.070 % to 0.120 % can be supplied by agreement between the purchaser and the supplier.

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

Steels		Normalizing temperature
Category 1 (1)	Category 2 (1)	
		°C
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	*860–900*
	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 1 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.

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

Steel (7)	Chemical composition						Condition (9)	Size (8) (diameter or across flats)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ min. (10)	HB
	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Carbon steels															
	%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
080M15	0.12–0.18	0.60–1.00					Normalized + turned or ground	⩾ 6 ⩽ 63	350 min.	175	22	–	–	–	109–163(4)
								> 63 ⩽ 150	330 min.	165	22	–	–	–	101–152(4)
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	450 min.	330	10				
								> 13 ⩽ 29	430 min.	320	12				
								> 29 ⩽ 100	400 min.	300	13				
070M20	0.16–0.24	0.50–0.90					Normalized + turned or ground	⩾ 6 ⩽ 150	430 min.	215	21	–	–	–	126–179(4)
								> 150 ⩽ 250	400 min.	200	21	–	–	–	116–170(4)
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	560 min.	440	10	–	–	420	
								> 13 ⩽ 16	530 min.	420	12	–	–	390	
								> 16 ⩽ 40	490 min	370	12	–	–	340	
								> 40 ⩽ 63	480 min.	355	13	–	–	290	
								> 63 ⩽ 76	450 min.	325	14	–	–	280	
070M26	0.22–0.30	0.50–0.90					Normalized + turned or ground	⩾ 6 ⩽ 63	490 min.	245	20	–	–	–	143–192(4)
								> 63 ⩽ 250	430 min.	215	20	–	–	–	126–179(4)
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	590 min.	465	9	–	–	440	
								> 13 ⩽ 16	570 min.	440	11	–	–	420	
								> 16 ⩽ 40	540 min.	400	12	–	–	380	
								> 40 ⩽ 63	530 min.	385	12	–	–	330	
								> 63 ⩽ 76	490 min.	355	13	–	–	310	
080M30	0.26–0.34	0.60–1.00					Normalized + turned or ground	⩾ 6 ⩽ 150	490 min.	245	20	–	–	–	143–192(4)
								> 150 ⩽ 250	460 min.	230	19	–	–	–	134–183(4)
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	620 min.	480	9	–	–	460	
								> 13 ⩽ 16	600 min.	470	10	–	–	450	
								> 16 ⩽ 40	570 min.	430	11	–	–	400	
								> 40 ⩽ 63	560 min.	415	12	–	–	345	
								> 63 ⩽ 76	530 min.	385	12	–	–	320	
							Hardened and tempered + turned or ground	P ⩾ 6 ⩽ 63	550–700	340	18	25	28	310	152–207
								Q ⩾ 6 ⩽ 19	625–775	415	16	25	28	400	179–229
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P ⩾ 6 ⩽ 63	550–700	385	13	25	–	340	152–207 (4)
								Q ⩾ 6 ⩽ 19	625–775	460	12	25	–	430	179–229 (4)

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 across flats)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Carbon steels															
	%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
080M40	0.36–0.44	0.60–1.00					Normalized + turned or ground	⩾ 6 ⩽ 150	550 min.	280	16	15	16	–	152–207(4)
								> 150 ⩽ 250	510 min.	245	17	–	–	–	146–197(4)
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	660 min.	530	7	–	–	495	
								> 13 ⩽ 16	650 min.	510	8	–	–	485	
								> 16 ⩽ 40	620 min.	480	9	–	–	435	
								> 40 ⩽ 63	600 min.	465	10	–	–	370	
								> 63 ⩽ 76	570 min.	430	10	–	–	350	
							Hardened and tempered + turned or ground	Q ⩾ 6 ⩽ 63	625–775	385	16	25	28	355	179–229
								R ⩾ 6 ⩽ 19	700–850	465	16	25	28	450	201–255
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q ⩾ 6 ⩽ 63	625–775	435	12	25	–	380	179–229 (4)
								R ⩾ 6 ⩽ 19	700–850	490	12	25	–	460	201–255 (4)
080M50	0.45–0.55	0.60–1.00					Normalized + turned or ground	⩾ 6 ⩽ 150	620 min.	310	14	–	–	–	179–229(4)
								> 150 ⩽ 250	570 min.	295	14	–	–	–	163–217(4)
							Normalized + cold drawn or normalized + cold drawn + ground	⩾ 6 ⩽ 13	740 min.	590	7	–	–	555	
								> 13 ⩽ 16	730 min.	585	8	–	–	545	
								> 16 ⩽ 40	690 min.	555	8	–	–	485	
								> 40 ⩽ 63	680 min.	540	9	–	–	420	
								> 63 ⩽ 76	650 min.	510	10	–	–	400	
							Hardened and tempered + turned or ground	Q ⩾ 6 ⩽ 150	625–775	390	15	–	–	360	179–229
								R ⩾ 6 ⩽ 63	700–850	430	14	–	–	400	201–255
								S ⩾ 6 ⩽ 29	775–925	495	14	–	–	465	223–277
								T (13) ⩾ 6 ⩽ 13	850–1000	570	12	–	–	555	248–302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q ⩾ 13 ⩽ 150	625–775	430	11	–	–	390	179–229 (4)
								R ⩾ 6 ⩽ 63	700–850	490	10	–	–	450	201–255 (4)
								S ⩾ 6 ⩽ 29	775–925	540	10	–	–	500	223–277 (4)
								T (13) ⩾ 6 ⩽ 13	850–1000	595	9	–	–	550	248–302 (4)
							Turned, ground or cold drawn and finally softened	–	–	–	–	–	–	–	187 max.

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 across flats)		R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Mn	Cr	Mo	Ni	Others							Izod min.	KCV min.		
	%	%	%	%	%	%			mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
070M55	0.50–0.60	0.50–0.90					Normalized + turned or ground		⩾ 6 ⩽ 63	700 min.	355	12	–	–	–	201–255(4)
									> 63 ⩽ 250	600 min.	310	13	–	–	–	170–223(4)
							Normalized + cold drawn or normalized + cold drawn + ground		⩾ 6 ⩽ 13	760 min.	610	6	–	–	570	
									> 13 ⩽ 16	750 min.	600	7	–	–	560	
									> 16 ⩽ 40	710 min.	575	7	–	–	495	
									> 40 ⩽ 63	700 min.	545	8	–	–	440	
									> 63 ⩽ 76	670 min.	530	9	–	–	420	
							Hardened and tempered + turned or ground	R	> 13 ⩽ 100	700–850	415	14	–	–	385	201–255
								S	⩾ 6 ⩽ 63	775–925	480	14	–	–	450	223–277
								T (13)	⩾ 6 ⩽ 19	850–1000	570	12	–	–	555	248–302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R	> 29 ⩽ 100	700–850	475	10	–	–	435	201–255(4)
								R	> 13 ⩽ 29	700–850	510	10	–	–	475	201–255(4)
								S	⩾ 6 ⩽ 63	775–925	525	10	–	–	485	223–277(4)
								T (13)	⩾ 6 ⩽ 19	850–1000	595	9	–	–	550	248–302(4)
							Turned, ground or cold drawn and finally softened	–		–	–	–	–	–	–	201 max.
Carbon manganese steels																
120M36	0.32–0.40	1.00–1.40					Normalized + turned or ground		⩾ 6 ⩽ 150	590 min.	355	15	–	–	–	174–223(4)
									> 150 ⩽ 250	570 min.	340	16	–	–	–	163–217(4)
							Hot rolled + cold drawn or hot rolled + cold drawn + ground		⩾ 6 ⩽ 13	710 min.	565	6	–	–	530	
									> 13 ⩽ 16	690 min.	555	7	–	–	510	
									> 16 ⩽ 40	660 min.	525	8	–	–	460	
									> 40 ⩽ 63	650 min.	510	9	–	–	400	
									> 63 ⩽ 76	620 min.	480	9	–	–	380	
							Hardened and tempered + turned or ground	Q	⩾ 6 ⩽ 100	625–775	415	18	30	35	385	179–229
								R	⩾ 6 ⩽ 29	700–850	510	16	25	28	480	201–255
								S	⩾ 6 ⩽ 19	775–925	570	14	25	28	555	223–277
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q	> 13 ⩽ 100	625–775	440	13	30	–	400	179–229(4)
								R	⩾ 6 ⩽ 29	700–850	520	12	25	–	450	201–255(4)
								S	⩾ 6 ⩽ 19	775–925	580	10	25	–	510	223–277(4)
150M19	0.15–0.23	1.30–1.70					Normalized + turned or ground		⩾ 6 ⩽ 150	550 min.	325	18	30	35	–	152–207(4)
									> 150 ⩽ 250	510 min.	295	17	–	–	–	146–197(4)
							Hardened and tempered + turned or ground	P	> 13 ⩽ 150	550–700	340	18	40	50	325	152–207
								Q	⩾ 6 ⩽ 63	625–775	430	16	40	50	415	179–229
								R	⩾ 6 ⩽ 29	700–850	510	16	30	35	495	201–255
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P	> 19 ⩽ 150	550–700	360	13	40	–	345	152–207(4)
								Q	⩾ 6 ⩽ 63	625–775	450	12	40	–	435	179–229(4)
								R	⩾ 6 ⩽ 29	700–850	520	12	30	–	510	201–255(4)

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 across flats)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
	%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft-lb	J	N/mm² (2)	
150M36	0.32–0.40	1.30–1.70					Normalized + turned or ground	⩾ 6 ⩽ 150	620 min.	385	14	–	–	–	179–229 (4)
								> 150 ⩽ 250	600 min.	355	15	–	–	–	170–223 (4)
							Hardened and tempered + turned or ground	Q > 19 ⩽ 150	625–775	400	18	35	42	370	179–229
								R > 13 ⩽ 63	700–850	480	16	30	35	450	201–255
								S ⩾ 6 ⩽ 29	775–925	555	14	30	35	525	223–277
								T (13) ⩾ 6 ⩽ 13	850–1000	635	12	25	28	620	248–302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q > 19 ⩽ 150	625–775	440	13	35	–	400	179–229 (4)
								R > 13 ⩽ 63	700–850	520	12	30	–	480	201–255 (4)
								S ⩾ 6 ⩽ 29	775–925	580	10	30	–	540	223–277 (4)
								T (13) ⩾ 6 ⩽ 13	850–1000	665	9	25	–	635	248–302 (4)
Non-alloy free-cutting steels															
220M07	0.15 max.	0.90–1.30				P 0.070 max. (6) S 0.20–0.30	Hot rolled + turned or ground	⩾ 6 ⩽ 100	360 min.	215	22	–	–	–	103 min.
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	480 min.	400	6	–	–	360	
								> 13 ⩽ 16	460 min.	380	7	–	–	345	
								> 16 ⩽ 40	430 min.	340	8	–	–	300	
								> 40 ⩽ 63	390 min.	280	9	–	–	240	
								> 63 ⩽ 76	370 min.	240	10	–	–	225	
230M07	0.15 max.	0.90–1.30				P 0.070 max. (6) S 0.25–0.35	Hot rolled + turned or ground	⩾ 6 ⩽ 100	360 min.	215	22	–	–	–	103 min.
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	480 min.	400	6	–	–	360	
								> 13 ⩽ 16	460 min.	380	7	–	–	345	
								> 16 ⩽ 40	430 min.	340	8	–	–	300	
								> 40 ⩽ 63	390 min.	280	9	–	–	240	
								> 63 ⩽ 76	370 min.	240	10	–	–	225	
216M36	0.32–0.40	1.30–1.70				Si 0.25 max. P 0.060 max. S 0.12–0.20	Hot rolled + cold drawn or hot rolled + cold drawn + ground	⩾ 6 ⩽ 13	680 min.	530	6	–	–	510	
								> 13 ⩽ 16	650 min.	510	7	–	–	487	
								> 16 ⩽ 40	620 min.	480	7	–	–	434	
								> 40 ⩽ 63	600 min.	460	8	–	–	372	
								> 63 ⩽ 76	570 min.	420	9	–	–	353	
							Hardened and tempered + turned or ground	P ⩾ 6 ⩽ 100	550–700	340	20	25	28	310	152–207
								Q ⩾ 6 ⩽ 63	625–775	400	18	25	28	370	179–229
								R ⩾ 6 ⩽ 29	700–850	480	16	25	28	450	201–255
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P > 29 ⩽ 100	550–700	380	15	25	–	340	152–207 (4)
								Q > 13 ⩽ 63	625–775	440	13	25	–	400	179–229 (4)
								R ⩾ 6 ⩽ 29	700–850	520	12	25	–	470	201–255 (4)

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 across flats)			R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Mn	Cr	Mo	Ni	Others								Izod min.	KCV min.		
	%	%	%	%	%	%			mm		N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
226M44	0.40–0.48	1.30–1.70				Si 0.25 max. P 0.060 max. S 0.22–0.30	Hardened and tempered + turned or ground	R	⩾ 6 ⩽ 100		700–850	450	16	20	22	415	201–255
								S	⩾ 6 ⩽ 29		775–925	525	14	15	16	495	223–277
								T (13)	⩾ 6 ⩽ 13		850–1000	600	12	15	16	585	248–302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R	⩾ 6 ⩽ 100		700–850	525	12	20	–	435	201–255 (4)
								S	⩾ 6 ⩽ 29		775–925	575	10	15	–	520	223–277 (4)
								T (13)	⩾ 6 ⩽ 13		850–1000	630	9	15	–	600	248–302 (4)
Alloy steels																	
530M40	0.36–0.44	0.60–0.90	0.90–1.20				Hardened and tempered + turned or ground	R	> 63 ⩽ 100		700–850	525	17	40	50	510	201–255
								S	⩾ 6 ⩽ 63		775–925	585	15	40	50	570	223–277
								T	⩾ 6 ⩽ 29		850–1000	680	13	40	50	665	248–302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R	> 63 ⩽ 100		700–850	540	12	40	–	525	201–255 (4)
								S	> 13 ⩽ 63		775–925	600	11	40	–	585	223–277 (4)
								T	⩾ 6 ⩽ 29		850–1000	700	9	40	–	680	248–302 (4)
							Turned, ground or cold drawn and finally softened										229 max.
605M36	0.32–0.40	1.30–1.70		0.22–0.32			Hardened and tempered + turned or ground	R	> 150 ⩽ 250		700–850	495	15	25	28	480	201–255
								R	> 29 ⩽ 150		700–850	525	17	40	50	510	201–255
								S	> 13 ⩽ 100		775–925	585	15	40	50	570	223–277
								T	⩾ 6 ⩽ 63		850–1000	680	13	40	50	665	248–302
								U	⩾ 6 ⩽ 29		925–1075	755	12	35	42	740	269–331
								V	⩾ 6 ⩽ 19		1000–1150	850	12	35	42	835	293–352
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R	> 29 ⩽ 150		700–850	540	12	40	–	525	201–255 (4)
								S	> 13 ⩽ 100		775–925	600	11	40	–	585	223–277 (4)
								T	⩾ 6 ⩽ 63		850–1000	700	9	40	–	680	248–302 (4)
								U	⩾ 6 ⩽ 29		925–1075	770	9	35	–	755	269–331 (4)
								V	⩾ 6 ⩽ 19		1000–1150	865	9	35	–	850	293–352 (4)
							Turned, ground or cold drawn, and finally softened										241 max.
606M36	0.32–0.40	1.30–1.70		0.22–0.32		P 0.060 max. S 0.15–0.25	Hardened and tempered + turned or ground	R	> 13 ⩽ 100		700–850	525	15	40	50	510	201–255
								S	⩾ 6 ⩽ 63		775–925	585	13	35	42	570	223–277
								T	⩾ 6 ⩽ 29		850–1000	680	11	30	35	665	248–302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R	> 29 ⩽ 100		700–850	540	11	35	–	525	201–255 (4)
								S	⩾ 6 ⩽ 63		775–925	600	10	35	–	585	223–277 (4)
								T	⩾ 6 ⩽ 29		850–1000	700	8	30	–	680	248–302 (4)
							Turned, ground or cold drawn and finally softened										229 max.

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 across flats)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
	%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft lb	J	N/mm² (2)	
708M40	0.36–0.44	0.70–1.00	0.90–1.20	0.15–0.25			Hardened and tempered + turned or ground	R > 150 ⩽ 250	700–850	495	15	25	28	480	201–255
								R > 63 ⩽ 150	700–850	525	17	40	50	510	201–255
								S > 29 ⩽ 100	775–925	585	15	40	50	570	223–277
								T ⩾ 6 ⩽ 63	850–1000	680	13	40	50	665	248–302
								U ⩾ 6 ⩽ 29	925–1075	755	12	35	42	740	269–331
								V ⩾ 6 ⩽ 19	1000–1150	850	12	35	42	835	293–352
								W (11) (13) ⩾ 6 ⩽ 13	1075–1225	940	12	30	35	925	311–375
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 63 ⩽ 150	700–850	540	12	40	–	525	201–255 (4)
								S > 29 ⩽ 100	775–925	600	11	40	–	585	223–277 (4)
								T ⩾ 6 ⩽ 63	850–1000	700	9	40	–	680	248–302 (4)
								U ⩾ 6 ⩽ 29	925–1075	770	9	35	–	755	269–331 (4)
								V ⩾ 6 ⩽ 19	1000–1150	865	9	35	–	850	293–352 (4)
								W (11) (13) ⩾ 6 ⩽ 13	1075–1225	955	8	30	–	940	311–375 (4)
							Turned, ground or cold drawn and finally softened								248 max.
709M40	0.36–0.44	0.70–1.00	0.90–1.20	0.25–0.36			Hardened and tempered + turned or ground	R > 100 ⩽ 250	700–850	495	15	25	28	480	201–255
								S > 150 ⩽ 250	775–925	555	13	20	22	540	223–277
								S > 63 ⩽ 150	775–925	585	15	40	50	570	223–277
								T > 29 ⩽ 100	850–1000	680	13	40	50	665	248–302
								U > 13 ⩽ 63	925–1075	755	12	35	42	740	269–331
								V ⩾ 6 ⩽ 29	1000–1150	850	12	35	42	835	293–352
								W (11) (13) ⩾ 6 ⩽ 19	1075–1225	940	12	30	35	925	311–375
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 100 ⩽ 150	700–850	540	11	40	–	510	201–255 (4)
								S > 63 ⩽ 150	775–925	600	11	40	–	585	223–277 (4)
								T > 29 ⩽ 100	850–1000	700	9	40	–	680	248–302 (4)
								U > 13 ⩽ 63	925–1075	770	9	35	–	755	269–331 (4)
								V ⩾ 6 ⩽ 29	1000–1150	865	9	35	–	850	293–352 (4)
								W (11) (13) ⩾ 6 ⩽ 19	1075–1225	955	8	30	–	940	311–375 (4)
							Turned, ground or cold drawn and finally softened								255 max.
722M24	0.20–0.28	0.45–0.70	3.00–3.50	0.45–0.65			Hardened and tempered + turned or ground	T ⩾ 6 ⩽ 250	850–1000	650	13	30	35	635	248–302
								T ⩾ 6 ⩽ 150	850–1000	680	13	40	50	665	248–302
								U ⩾ 6 ⩽ 150	925–1075	755	12	35	42	740	269–331
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	T ⩾ 6 ⩽ 150	850–1000	700	9	40	–	680	248–302 (4)
								U ⩾ 6 ⩽ 150	925–1075	770	9	35	–	755	269–331 (4)
							Turned, ground or cold drawn and finally softened								269 max.

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

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 *(concluded)*

Steel (7)	Chemical composition						Condition (9)	Size (8) (diameter or across flats)		R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Mn	Cr	Mo	Ni	Others							Izod min.	KCV min.		
	%	%	%	%	%	%			mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
817M40	0.36–0.44	0.45–0.70	1.00–1.40	0.20–0.35	1.30–1.70		Hardened and tempered + turned or ground	T	> 150 ⩽ 250	850–1000	650	13	30	35	635	248–302
								T	> 63 ⩽ 150	850–1000	680	13	40	50	665	248–302
								U	> 29 ⩽ 100	925–1075	755	12	35	42	740	269–331
								V	> 13 ⩽ 63	1000–1150	850	12	35	42	835	293–352
								W (11)	⩾ 6 ⩽ 29	1075–1225	940	11	30	35	925	311–375
								X (11)	⩾ 6 ⩽ 29	1150–1300	1020	10	25	28	1005	341–401
								Z (11)	⩾ 6 ⩽ 29	1550 min.	1235	5	8	9	1125	444 min.
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	T	> 63 ⩽ 150	850–1000	700	9	40	—	680	248–302 (4)
								U	> 29 ⩽ 100	925–1075	770	9	35	—	755	269–331 (4)
								V	> 13 ⩽ 63	1000–1150	865	9	35	—	850	293–352 (4)
								W (11)	⩾ 6 ⩽ 29	1075–1225 (12)	955	8	30	—	940	311–375 (4)
								X (11)	⩾ 6 ⩽ 29	1150–1300 (12)	1035	7	25	—	1020	341–401 (4)
								Z (11)	⩾ 6 ⩽ 29	1550 min. (12)	1250	3	8	—	1235	444 min. (4)
							Turned, ground or cold drawn and finally softened									277 max.
826M40	0.36–0.44	0.45–0.70	0.50–0.80	0.45–0.65	2.30–2.80		Hardened and tempered + turned or ground	U	> 150 ⩽ 250	925–1075	740	12	25	28	725	269–331
								U	> 100 ⩽ 150	925–1075	755	12	35	42	740	269–331
								V	> 63 ⩽ 250	1000–1150	835	12	25	28	820	293–352
								V	> 63 ⩽ 150	1000–1150	850	12	35	42	835	293–352
								W (11)	> 29 ⩽ 250	1075–1225	925	11	20	22	910	311–375
								W (11)	> 29 ⩽ 150	1075–1225	940	11	30	35	925	311–375
								X (11)	> 29 ⩽ 150	1150–1300	1020	10	25	28	1005	341–401
								Y (11)	> 29 ⩽ 150	1225–1375	1095	10	25	28	1080	363–429
								Z (11)	> 29 ⩽ 100	1550 min.	1235	7	10	11	1125	444 min.
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	U	> 100 ⩽ 150	925–1075	770	9	35	—	755	269–331 (4)
								V	> 63 ⩽ 150	1000–1150	865	9	35	—	850	293–352 (4)
								W (11)	> 29 ⩽ 150	1075–1225 (12)	955	8	30	—	940	311–375 (4)
								X (11)	> 29 ⩽ 150	1150–1300 (12)	1035	7	25	—	1020	341–401 (4)
								Y (11)	> 29 ⩽ 150	1225–1375 (12)	1010	7	25	—	1095	363–429 (4)
								Z (11)	> 29 ⩽ 100	1550 min. (12)	1250	5	10	—	1235	444 min. (4)
							Turned, ground or cold drawn and finally softened									277 max.

(2) 1 N/mm² = 1 MPa.

(4) For guidance only.

(6) Higher phosphorus contents or ranges, for example 0.040 % to 0.090 % or 0.070 % to 0.120 % can be supplied by agreement between the purchaser and the supplier.

(7) All the steels are category 1, see also foreword.

(8) For cold drawn bar of ⩽ 6 mm diameter or *a/f*, all mechanical properties shall be the subject of agreement between the purchaser and the supplier at the time of enquiry and order.

(9) For normalizing and hardening and tempering treatments, see tables 3 and 7.

(10) When specifically ordered.

(11) Often ordered in the softened condition for machining and subsequent heat treatment to achieve these specified mechanical properties.

(12) Cold drawn bars are not normally available in this tensile strength range.

(13) May not always be obtained by bulk heat treatment but the properties can be achieved by the appropriate heat treatment of die forgings and components (see note to **1.4.4.2.1**) and also apply to test bars

2.3 Specific requirements for micro-alloyed carbon manganese steels

The steels included in this subclause develop their properties by the addition of small amounts of vanadium or other micro-alloying elements, together with control of hot working temperature and subsequent air cooling* and in the finished condition have a ferrite/pearlite structure, free from bainite. They offer, for certain applications, an alternative route to obtaining hardness and tensile strength normally associated with medium carbon and alloy steels in the hardened and tempered condition.

Since the analysis of the steel necessary to attain the specified properties depends on processing conditions and section size, it is not possible to state specific analysis requirements. The analysis, however, should be selected from within the broad range specified in table 5, according to the particular end conditions and strength grade required. In order to be free from bainite, due account has to be taken of those elements which may form this constituent, e.g. Mo, Mn, Cr, Ni and Cu. When necessary, metallurgical advice should be sought.

To aid machinability, it may be necessary for the microstructure of the forged part to be agreed.

*For this reason the use of separate test bars is not recommended.

able 5. Micro-alloyed carbon manganese steels: hemical composition and mechanical property requirements

eel (7)	Chemical composition							Condition (14)	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact KCV min.	HB
	C	Si	Mn	P	S	V	Al							
	%	%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		J	
;0M01	0.30–0.55	0.15–0.60	0.60–1.50	0.035 max	0.045–0.065 (15)	0.08–0.20 (16)	0.035 max.	S	100	775–925	530	14	10	223–277
								T	100	850–1000	560	12	8	248–302
								U	100	925–1075	600	10	8	269–331

2) 1 N/mm² = 1 MPa.

7) Category 1 steel, see also foreword.

4) Whilst these tensile strength ranges are identical with those for the through hardened and tempered steels (see section three), in this case they are not achieved by hardening and tempering. It should be noted that the other properties these steels may differ from those for the hardened and tempered steels; see note 3 to **1.6.4.2** with respect to grain size.

5) The steel may be supplied with a sulphur content of 0.050 % maximum or, to obtain improved machinability, with 0.065 % to 0.10 % sulphur.

6) Other micro-alloying additions (such as Nb, Ti) may be made, either singly or in combination, in which case the total, as determined by product analysis, shall be in the range 0.08 % to 0.20 %.

Section three. Specific requirements for through hardening steels including steels capable of surface hardening by nitriding (for requirements for hot rolled and normalized steels, see section 2.1)

This section brings together all the steels used in the through hardened and tempered condition, whether they be carbon or alloy, and also separates them from other conditions of the steels which will be found in 2.1 and 2.2. Additionally, the steels in this section have been divided into two categories, see foreword. Category 1 steels should be used for new designs and for established designs whenever this is possible, carrying out validity tests if necessary. Assistance in selecting the most efficient category 1 steel is given in appendix C.

Of the steels used in the through hardened and tempered condition and specified in the previous edition, 14 mechanical property grade M steels have been omitted and 4 new M steels added. Apart from steels 070M20 and 070M26, which will now be found in 2.1 and 2.2, the principal reason for the deletion of the 12 other grades is availability of more efficient alternatives, see appendix C.

Table 6. Through hardening steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements

(for hardenability requirements, see tables 8 and 9; for requirements for hot rolled and normalized steels, see **2.1**)

Steel		Chemical composition						Heat treatment condition	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Carbon steels																
		%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
080M30		0.26–0.34	0.60–1.00					P	63	550–700	340	18	25	28	310	152–207
								Q	19	625–775	415	16	25	28	400	179–229
	080A30	*0.28–0.33*	*0.70–0.90*													
	060A32	*0.30–0.35*	*0.50–0.70*													
	080A32	*0.30–0.35*	*0.70–0.90*													
080M36		0.32–0.40	0.60–1.00					Q	29	625–775	400	16	25	28	370	179–229
								R	13	700–850	465	16	25	28	450	201–255
	080H36	*0.33–0.40*	*0.60–1.00*													
	080A35	*0.33–0.38*	*0.70–0.90*													
	080A37	*0.35–0.40*	*0.70–0.90*													
080M40		0.36–0.44	0.60–1.00					Q	63	625–775	385	16	25	28	355	179–229
								R	19	700–850	465	16	25	28	450	201–255
	080H41	*0.38–0.45*	*0.60–1.00*													
	060A40	*0.38–0.43*	*0.50–0.70*													
	080A40	*0.38–0.43*	*0.70–0.90*													
	080A42	*0.40–0.45*	*0.70–0.90*													
080M46		0.42–0.50	0.60–1.00					Q	100	625–775	370	16	–	–	340	179–229
								R	29	700–850	450	16	–	–	415	201–255
080H46		0.43–0.50	0.60–1.00					S	13	775–925	525	14	–	–	510	223–277
	060A45	*0.43–0.48*	*0.50–0.70*													
080M50		0.45–0.55	0.60–1.00					Q	150	625–775	390	15	–	–	360	179–229
								R	63	700–850	430	14	–	–	400	201–255
								S	29	775–925	495	14	–	–	465	223–277
	060A47	*0.45–0.50*	*0.50–0.70*					T(13)	13	850–1000	570	12	–	–	555	248–302
	080A47	*0.45–0.50*	*0.70–0.90*													
070M55		0.50–0.60	0.50–0.90					R	100	700–850	415	14	–	–	385	201–255
								S	63	775–925	480	14	–	–	450	223–277
								T(13)	19	850–1000	570	12	–	–	555	248–302
	080A52	*0.50–0.55*	*0.70–0.90*													
	060A57	*0.55–0.60*	*0.50–0.70*													
	080A57	*0.55–0.60*	*0.70–0.90*													

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

Table 6. Through hardening steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements *(continued)*

Steel		Chemical composition						Heat treatment condition	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$(10) min.	HB
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Carbon manganese steels																
		%	%	%	%	%	%		mm	N/mm²(2)	N/mm²(2)		ft·lb	J	N/mm²(2)	
	120M19	*0.15–0.23*	*1.00–1.40*					*P*	*100*	*550–700*	*355*	*18*	*35*	*42*	*325*	*152–207*
								Q	*29*	*625–775*	*450*	*16*	*35*	*42*	*415*	*179–229*
								R	*19*	*700–850*	*510*	*16*	*25*	*28*	*495*	*201–255*
120M36		0.32–0.40	1.00–1.40					Q	100	625–775	415	18	30	35	385	179–229
								R	29	700–850	510	16	25	28	480	201–255
								S	19	775–925	570	14	25	28	555	223–277
135M44		0.40–0.48	1.20–1.50					Q	150	625–775	415	16	35	42	385	179–229
								R	100	700–850	490	15	30	35	460	201–255
								S	29	775–925	580	14	30	35	550	223–277
								T(13)	19	850–1000	650	12	25	28	620	248–302
								U(13)	13	925–1075	700	10	20	22	670	269–331
150M19		0.15–0.23	1.30–1.70					P	150	550–700	340	18	40	50	325	152–207
								Q	63	625–775	430	16	40	50	415	179–229
								R	29	700–850	510	16	30	35	495	201–255
	150M28	*0.24–0.32*	*1.30–1.70*					*Q*	*150*	*625–775*	*400*	*16*	*35*	*42*	*370*	179–229
								R	*63*	*700–850*	*480*	*16*	*30*	*35*	*450*	201–255
								S	*13*	*775–925*	*570*	*16*	*25*	*28*	*555*	223–277
150M36		0.32–0.40	1.30–1.70					Q	150	625–775	400	18	35	42	370	179–229
								R	63	700–850	480	16	30	35	450	201–255
								S	29	775–925	555	14	30	35	525	223–277
								T(13)	13	850–1000	635	12	25	28	620	248–302
	150M40	*0.36–0.44*	*1.30–1.70*					*Q*	*150*	*625–775*	*400*	*18*	*35*	*42*	*370*	*179–229*
								R	*63*	*700–850*	*480*	*16*	*30*	*35*	*450*	*201–255*
								S	*29*	*775–925*	*555*	*14*	*25*	*28*	*525*	*223–277*
								T(13)	*13*	*850–1000*	*635*	*12*	*20*	*22*	*620*	*248–302*

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

Table 6. Through hardening steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements *(continued)*

Steel		Chemical composition						Heat treatment condition	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Carbon manganese free cutting steels																
		%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
	216M28	*0.24–0.32*	*1.10–1.50*				*Si 0.25 max.* *P 0.060 max.* *S 0.12–0.20*	*P* *Q*	*63* *19*	*550–700* *625–775*	*355* *430*	*20* *18*	*25* *25*	*28* *28*	*325* *415*	*152–207* *179–229*
212M36		0.32–0.40	1.00–1.40				Si 0.25 max. P 0.060 max. S 0.12–0.20	P Q R	100 63 13	550–700 625–775 700–850	340 400 495	20 18 16	25 25 25	28 28 28	310 370 480	152–207 179–229 201–255
	212A37	*0.35–0.40*	*1.00–1.30*				*P 0.060 max.* *S 0.12–0.20*									
	212A42	*0.40–0.45*	*1.00–1.30*				*P 0.060 max.* *S 0.12–0.20*									
	225M36	*0.32–0.40*	*1.00–1.40*				*Si 0.25 max.* *P 0.060 max.* *S 0.20–0.30*	*Q* *R*	*63* *13*	*625–775* *700–850*	*400* *480*	*18* *16*	*25* *25*	*28* *28*	*370* *450*	*179–229* *201–255*
216M36		0.32–0.40	1.30–1.70				Si 0.25 max. P 0.060 max. S 0.12–0.20	P Q R	100 63 29	550–700 625–775 700–850	340 400 480	20 18 16	25 25 25	28 28 28	310 370 450	152–207 179–229 201–255
216M44		0.40–0.48	1.20–1.50				P 0.060 max. S 0.12–0.20	Q R S T(13)	150 100 29 13	625–775 700–850 775–925 850–1000	400 450 525 600	16 15 14 12	20 15 15 15	22 16 16 16	370 415 495 585	179–229 201–255 223–277 248–302
	216A42	*0.40–0.45*	*1.20–1.50*				*P 0.060 max.* *S 0.12–0.20*(17)									
226M44		0.40–0.48	1.30–1.70				Si 0.25 max. P 0.060 max. S 0.22–0.30	R S T(13)	100 29 13	700–850 775–925 850–1000	450 525 600	16 14 12	20 15 15	22 16 16	415 495 585	201–255 223–277 248–302
Boron steels																
170H20		0.17–0.23	0.80–1.10				Soluble B 0.0005–0.005(18)									
170H36		0.32–0.39	0.80–1.10				Soluble B 0.0005–0.005(18)									
170H41		0.37–0.44	0.80–1.10				Soluble B 0.0005–0.005(18)									
185H40		0.36–0.45	1.25–1.75	0.15–0.35	0.08–0.18		Soluble B 0.0005–0.005(18) S 0.03–0.06									

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

Table 6. Through hardening steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements *(continued)*

Steel		Chemical composition						Heat treatment condition	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Alloy steels																
		%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
530M40		0.36–0.44	0.60–0.90	0.90–1.20				R	100	700–850	525	17	40	50	510	201–255
								S	63	775–925	585	15	40	50	570	223–277
								T	29	850–1000	680	13	40	50	665	248–302
530H32		0.29–0.35	0.50–0.90	0.80–1.25												
530H36		0.33–0.40	0.50–0.90	0.80–1.25												
530H40		0.37–0.44	0.50–0.90	0.80–1.25												
	530A30	*0.28–0.33*	*0.60–0.80*	*0.90–1.20*												
	530A32	*0.30–0.35*	*0.60–0.80*	*0.90–1.20*												
	530A36	*0.34–0.39*	*0.60–0.80*	*0.90–1.20*												
	530A40	*0.38–0.43*	*0.60–0.80*	*0.90–1.20*												
535A99		0.95–1.10	0.40–0.70	1.20–1.60												229 max. (19)
605M36		0.32–0.40	1.30–1.70		0.22–0.32			R	250	770–850	495	15	25	28	480	201–255
								R	150	700–850	525	17	40	50	510	201–255
								S	100	755–925	585	15	40	50	570	223–277
								T	63	850–1000	680	13	40	50	665	248–302
								U	29	925–1075	755	12	35	42	740	269–331
								V	19	1000–1150	850	12	35	42	835	293–352
	605H32	*0.29–0.35*	*1.25–1.75*		*0.22–0.32*											
	605H37	*0.34–0.41*	*1.25–1.75*		*0.22–0.32*											
	605A32	*0.30–0.35*	*1.30–1.70*		*0.22–0.32*											
	605A37	*0.35–0.40*	*1.30–1.70*		*0.22–0.32*											
606M36		0.32–0.40	1.30–1.70		0.22–0.32		P 0.060 max. S 0.15–0.25	R	100	700–850	525	15	40	50	510	201–255
								S	63	775–925	585	13	35	42	570	223–277
								T	29	850–1000	680	11	30	35	665	248–302
708M40 (21)		0.36–0.44	0.70–1.00	0.90–1.20	0.15–0.25			Q	250	625–775	450	15	25	28	430	179–229
								Q	150	625–775	480	18	15	16	465	179–229
								R	250	700–850	495	15	25	28	480	201–255
								R	150	700–850	525	17	40	50	510	201–255
								S	100	775–925	585	15	40	50	570	223–277
								T	63	850–1000	680	13	40	50	665	248–302
								U	29	925–1075	755	12	35	42	740	269–331
								V	19	1000–1150	850	12	35	42	835	293–352
								W (11)(13)	13	1075–1225	940	12	30	35	925	311–375
708H37		0.34–0.41	0.65–1.05	0.80–1.25	0.15–0.25											
708H42		0.39–0.46	0.65–1.05	0.80–1.25	0.15–0.25											
708H45		0.42–0.49	0.65–1.05	0.80–1.25	0.15–0.25											
	708A25	*0.23–0.28*	*0.50–0.80*	*0.90–1.20*	*0.15–0.25*											
	708A30	*0.28–0.33*	*0.40–0.60*	*0.90–1.20*	*0.15–0.25*											
	708A37	*0.35–0.40*	*0.70–0.90*	*0.90–1.20*	*0.15–0.25*											
	708A40	*0.38–0.43*	*0.75–1.00*	*0.90–1.20*	*0.15–0.25*											
	708A42	*0.40–0.45*	*0.75–1.00*	*0.90–1.20*	*0.15–0.25*											
	708A47	*0.45–0.50*	*0.75–1.00*	*0.90–1.20*	*0.1[illegible]25*											

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

	0.45–0.50	*0.75–1.00*	*0.90–1.20*	*0.15–0.25*													

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

Table 6. Through hardening steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements *(continued)*

Steel		Chemical composition						Heat treatment condition	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Alloy steels *(continued)*																
		%	%	%	%	%	%		mm	N/mm² (2)	N/mm² (2)		ft lb	J	N/mm² (2)	
709M40 (21)		0.36–0.44	0.70–1.00	0.90–1.20	0.25–0.35			R	250	700–850	495	15	25	28	480	201–255
								S	250	775–925	555	13	20	22	540	223–277
								S	150	775–925	585	15	40	50	570	223–277
								T	100	850–1000	680	13	40	50	665	248–302
								U	63	925–1075	755	12	35	42	740	269–331
								V	29	1000–1150	850	12	35	42	835	293–352
								W (11) (13)	19	1075–1225	940	12	30	35	925	311–375
	709A37	*0.35–0.40*	*0.75–1.00*	*0.90–1.20*	*0.25–0.35*											
	709A40	*0.38–0.43*	*0.75–1.00*	*0.90–1.20*	*0.25–0.35*											
	709A42	*0.40–0.45*	*0.75–1.00*	*0.90–1.20*	*0.25–0.35*											
720M32		0.28–0.35	0.40–0.70	2.80–3.30	0.40–0.60			U	250	925–1075	755	12	30	35	740	269–331
								U	150	925–1075	755	12	35	42	740	269–331
								V	150	1000–1150	850	12	35	42	835	293–352
								W (11)	100	1075–1225	940	11	30	35	925	311–375
722M24 (22)		0.20–0.28	0.45–0.70	3.00–3.50	0.45–0.65			T	250	850–1000	650	13	30	35	635	248–302
								T	150	850–1000	680	13	40	50	665	248–302
								U	150	925–1075	755	12	35	42	740	269–331
817M40		0.36–0.44	0.45–0.70	1.00–1.40	0.20–0.35	1.30–1.70		T	250	850–1000	650	13	30	35	635	248–302
								T	150	850–1000	680	13	40	50	665	248–302
								U	100	925–1075	755	12	35	42	740	269–331
								V	63	1000–1150	850	12	35	42	835	293–352
								W (11)	29	1075–1225	940	11	30	35	925	311–375
								X (11)	29	1150–1300	1020	10	25	28	1005	341–401
								Y (11)	29	1225–1375	1095	10	18	21	1080	363–429
							P 0.025 max. (20) S 0.025 max. (20)	Z (11)	29	1550 min.	1235	5	8	9	1125	444 min.
	817A37	*0.35–0.40*	*0.45–0.70*	*1.00–1.40*	*0.20–0.35*	*1.30–1.70*										
	817A42	*0.40–0.45*	*0.45–0.70*	*1.00–1.40*	*0.20–0.35*	*1.30–1.70*										
	826M31	*0.27–0.35*	*0.45–0.70*	*0.50–0.80*	*0.45–0.65*	*2.30–2.80*		*T*	*250*	*850–1000*	*650*	*13*	*30*	*35*	*635*	*248–302*
								T	*150*	*850–1000*	*680*	*13*	*40*	*50*	*665*	*248–302*
								U	*250*	*925–1075*	*740*	*12*	*25*	*28*	*725*	*269–331*
								U	*150*	*925–1075*	*755*	*12*	*35*	*42*	*740*	*269–331*
								V	*150*	*1000–1150*	*850*	*12*	*35*	*42*	*835*	*293–352*
								W (11)	*100*	*1075–1225*	*940*	*11*	*30*	*35*	*925*	*311–375*
								X (11)	*63*	*1150–1300*	*1020*	*10*	*25*	*28*	*1005*	*341–401*
							P 0.025 max. (20) *S 0.025 max. (20)*	*Z (11)*	*63*	*1550 min.*	*1235*	*5*	*8*	*9*	*1125*	*444 min.*

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

Table 6. Through hardening steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements *(concluded)*

Steel		Chemical composition						Heat treatment condition	LRS	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$(10) min.	HB
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others						Izod min.	KCV min.		
Alloy steels *(concluded)*																
		%	%	%	%	%	%		mm	N/mm²(2)	N/mm²(2)		ft·lb	J	N/mm²(2)	
826M40		0.36–0.44	0.45–0.70	0.50–0.80	0.45–0.65	2.30–2.80	P 0.025 max.(20) S 0.025 max.(20)	U	250	925–1075	740	12	25	28	725	269–331
								U	150	925–1075	755	12	35	42	740	269–331
								V	250	1000–1150	835	12	25	28	820	293–352
								V	150	1000–1150	850	12	35	42	835	293–352
								W(11)	250	1075–1225	925	11	20	22	910	311–375
								W(11)	150	1075–1225	940	11	30	35	925	311–375
								X(11)	150	1150–1300	1020	10	25	28	1005	341–401
								Y(11)	150	1225–1375	1095	10	25	28	1080	363–429
								Z(11)	100	1550 min.	1235	7	10	11	1125	444 min.
835M30		0.26–0.34	0.45–0.70	1.10–1.40	0.20–0.35	3.90–4.30	P 0.025 max. S 0.025 max.	Z(11)	150	1550 min.	1235	7	15	16	1125	444 min.
	897M39(23)	*0.35–0.43*	*0.45–0.70*	*3.00–3.50*	*0.80–1.10*		*P 0.025 max. S 0.025 max. V 0.15–0.25*	—	*63*	*1310 min.*	*1160*	*8*	*15*	*16*	*1110*	*375 min.*
905M39(23)		0.35–0.43	0.40–0.65	1.40–1.80	0.15–0.25		P 0.025 max. S 0.025 max. Al 0.90–1.30	R	150	700–850	525	17	40	50	510	201–255
								S	100	775–925	585	15	40	50	570	223–277
								T	63	850–1000	680	13	35	42	665	248–302
	945M38	*0.34–0.42*	*1.20–1.60*	*0.40–0.60*	*0.15–0.25*	*0.60–0.90*		*R*	*250*	*700–850*	*495*	*15*	*25*	*28*	*480*	*201–255*
								R	*150*	*700–850*	*525*	*17*	*40*	*50*	*510*	*201–255*
								S	*100*	*775–925*	*585*	*15*	*40*	*50*	*570*	*223–277*
								T	*63*	*850–1000*	*680*	*13*	*40*	*50*	*665*	*248–302*
								U	*29*	*925–1075*	*755*	*12*	*35*	*42*	*740*	*269–331*
								V	*29*	*1000–1150*	*850*	*12*	*35*	*42*	*835*	*293–352*

(1) See note to **1.4.1.**

(2) 1 N/mm² = 1 MPa.

(10) When specifically ordered.

(11) Often ordered in the softened condition for machining and subsequent heat treatment to achieve these specified mechanical properties.

(13) May not always be obtained by bulk heat treatment but the properties can be achieved by the appropriate heat treatment of die forgings and components (see note to **1.4.4.2.1**) and also apply to test bars.

(17) May be ordered to narrower ranges of sulphur.

(18) Total boron may be determined providing the hardenability values are realized.

(19) When supplied in the softened condition.

(20) Unless otherwise agreed.

(21) Suitable for nitriding when so ordered by the purchaser in which case 4 × P plus Sn ⩽ 0.15 %.

(22) Suitable for nitriding when so ordered by the purchaser in which case 4 × P plus Sn ⩽ 0.12 %.

(23) Suitable for nitriding when so ordered by the purchaser in which case 4 × P plus Sn ⩽ 0.10 %.