PUBLISHED DOCUMENT

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Incorporating Corrigendum No. 1

Wrought steels for mechanical and allied engineering purposes — Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels

ICS 77.140.20

BSI British Standards

Committees responsible for this Published Document

The preparation of this Published Document was entrusted to Technical Committee ISE/31, Wrought steels, upon which the following bodies were represented:

Confederation of British Metalforming
Institute of Spring Technology
National Association of Steel Stockholders
Society of Motor Manufacturer's and Traders Association
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Contents

Foreword

This Published Document has been prepared by Technical Committee ISE/31. It supersedes PD 970:2001, which is withdrawn.

Some errors in PD 970:2001 have been corrected and some steel grades that are in regular use in the UK have been introduced as they did not have equivalents in the newly published European Standards and the withdrawal of BS 970 in which they were listed had resulted in them not being identified within any current document.

BS 970-1:1996 is to be withdrawn and has been largely replaced by BS EN 10083:1991 (soon to be revised), BS EN 10084:1998, BS EN 10087:1999, BS EN 10088:1995, BS EN 10095:1999 and BS EN 10250-4:2000.

BS 970-2:1988 is withdrawn and has been replaced by BS EN 10089:2002. BS 970-3:1991 is withdrawn and has been replaced by BS EN 10277:1999 and BS EN 10278:1999. BS 970-4 is withdrawn and has been replaced by BS EN 10090:1998.

The series of European Standards listed below covers heat treatable and engineering steels for both black and cold finished bar that were present in BS 970-1:1996 and BS 970-3:1991, or other European Standards.

Steel grades

BS EN 10083-1, *Quenched and tempered steels — Part 1: Technical delivery conditions for special steels.*

BS EN 10083-2, *Quenched and tempered steels — Part 2: Technical delivery conditions for unalloyed quality steels.*

BS EN 10083-3, *Quenched and tempered steels — Part 3: Technical delivery conditions for boron steels.*

BS EN 10084, *Case hardening steels — Technical delivery conditions.*

BS EN 10085, *Nitriding steels — Technical delivery conditions.*

BS EN 10087, *Free cutting steels — Technical delivery conditions for semi-finished products, hot rolled bars and rods.*

BS EN 10088-1, *Stainless steels — Part 1: List of stainless steels.*

BS EN 10088-3, *Stainless steels — Part 3: Technical delivery conditions for semi-finished products, bars, rods and sections for general purposes.*

BS EN 10089, *Hot rolled steels for quenched and tempered springs — Technical delivery conditions.*

BS EN 10090, *Valve steels and alloys for internal combustion engines.*

BS EN 10095, *Heat resisting steels and nickel alloys.*

BS EN 10250-2, *Open die steel forgings for general engineering purposes — Part 2: Non-alloy quality and special steels.*

BS EN 10250-3, *Open die steel forgings for general engineering purposes — Part 3: Alloy special steels.*

BS EN 10250-4, *Open die steel forgings for general engineering purposes — Part 4: Stainless steels.*

BS EN 10267, *Ferritic-pearlitic steels for precipitation hardening from hot working temperatures.*

BS EN 10277-1, *Bright steel products — Technical delivery conditions — Part 1: General.*

BS EN 10277-2, *Bright steel products — Technical delivery conditions — Part 2: Steels for general engineering purposes.*

BS EN 10277-3, *Bright steel products — Technical delivery conditions — Part 3: Free-cutting steels.*

BS EN 10277-4, *Bright steel products — Technical delivery conditions — Part 4: Case-hardening steels.*

BS EN 10277-5, *Bright steel products — Technical delivery conditions — Part 5: Steels for quenching and tempering.*

BS EN ISO 683-17, *Heat-treated steels, alloy steels and free-cutting steels — Part 17: Ball and roller bearing steels.*

Dimensions, tolerances and surface quality

BS EN 10058, *Hot rolled flat steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

BS EN 10059, *Hot rolled square steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

BS EN 10060, *Hot rolled round steel bars — Dimensions and tolerances on shape and dimensions.*

BS EN 10061, *Hot rolled hexagon steel bars — Dimensions and tolerances on shape and dimensions.*

BS EN 10092-1, *Hot rolled spring steel flat bars — Part 1: Flat bars — Dimensions and tolerances on shape and dimensions.*

BS EN 10092-2, *Hot rolled spring steel flat bars — Part 2: Ribbed and grooved spring leaves — Dimensions and tolerances on shape and dimensions.*

BS EN 10221, *Specification for surface quality classes for hot rolled bars and rods — Technical delivery conditions.*

BS EN 10250-1, *Open die steel forgings for general engineering purposes — Part 1: General requirements.*

BS EN 10278, *Dimensions and tolerances of bright steel products.*

BS EN 20286-2, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts.*

UK Steel Standard UKS01, *Semi-finished steel products for the manufacture of hot rolled bar, rod and sections*[1)][1].

Any steel grade that has previously appeared in BS 970:1983 and is now specified as an equivalent grade in one of the above European Standards is cross-referenced in Annex A which is informative.

This Published Document is not to be regarded as a British Standard.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 43 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

[1)] UKS01 is available from UK Steel, EEF, Broadway House, Tothill Street, London SW1H 9NQ.

1 Scope

This Published Document specifies the technical purchase and supply requirements for the following wrought semi-finished products manufactured from a range of carbon, carbon manganese, low alloy, free-cutting, case-hardening and through hardened steels for the following special applications:

— blooms;
— billets;
— slabs;
— bars;
— rod;
— flats and wide flats.

NOTE These wrought steels may be supplied in the hot formed condition or as thermally treated black bar. Cold finished bar may be subjected to pre- or post-thermal treatment.

It does not specify any boron, micro-alloyed, stainless steels or any products delivered as forgings, which are all covered by other standards (see Foreword).

It does not apply to direct cast products.

PD 970 is presented in the style of a European Standard and references other European Standards (e.g. test methods) wherever possible. The traditional seven digit alphanumeric UK designation is maintained, though it is important to note that the "A", "M" and "H" system (nominally representing Analysis, Mechanical and Hardenability) should not be confused with other nomenclature. This applies equally to the conventional tensile strength range designations, namely P through to Z which are still used in this document.

Certain other aspects such as requirements for steelmaking, deoxidation and grain size have been revised to reflect modern technology.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 131-1, *Notched bar tests — Part 1: The Izod impact test of metals.*

BS EN 10002-1, *Tensile testing of metallic materials — Part 1: Method of test at ambient temperature.*

BS EN 10020, *Definition and classification of grades of steel.*

BS EN 10021, *General technical delivery requirements for steel and iron products.*

BS EN 10045-1, *Charpy impact test on metallic materials — Part 1: Test method (V- and U-notches).*

BS EN 10052, *Vocabulary of heat treatment terms for ferrous products.*

BS EN 10058, *Hot rolled flat steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

BS EN 10059, *Hot rolled square steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

BS EN 10060, *Hot rolled round steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

BS EN 10061, *Hot rolled hexagonal steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

BS EN 10079, *Definition of steel products.*

BS EN 10204, *Metallic products — Types of inspection documents.*

BS EN 10278, *Dimensions and tolerances of bright steel products.*

BS EN 20286-2:1993, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts.*

BS EN ISO 642, *Steel hardenability test by end quenching (Jominy test).*

BS EN ISO 643, *Steels – Micrographic determination of the apparent grain size.*

BS EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method.*

BS EN ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method.*

BS EN ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T).*

DD ENV 606, *Bar coded transport and handling labels for steel products.*

3 Terms and definitions

For the purpose of this Published Document the terms and definitions given in BS EN 10020, BS EN 10021, BS EN 10052 and BS EN 10079 and the following apply.

3.1
ruling section
equivalent diameter of that portion of a product at the time of heat treatment that is most important in relation to mechanical properties

3.2
limiting ruling section
largest diameter in which certain specified mechanical properties are achieved after a specified heat treatment

3.3
equivalent diameter
diameter at the time of heat treatment of a hypothetical very long bar, effectively of infinite length and uniform circular cross-section, which, if subjected to the same cooling conditions as the product would have a cooling rate at its axis equivalent to that at the slowest cooling position in the product or relevant part

NOTE 1 This definition applies to any product or part of a product.

NOTE 2 The same cooling conditions means the same initial and final temperature and the same cooling medium.

4 Designation

The steel grades shall be designated in accordance with the system used previously in BS 970. “A” grades shall refer to close limits of chemical composition where no mechanical properties or hardenability are required. “M” and “H” grades shall refer to mechanical and hardenability requirements which are specified in combination with a chemical composition which may be wider than that given for “A” grades.

NOTE Material may be ordered and supplied without heat treatment where appropriate test pieces have been heat treated and tested to prove the capability of the material to meet the required properties.

Unless otherwise agreed at the time of enquiry or order the products shall be delivered in the untreated, i.e. hot worked condition.

5 Information to be supplied by the purchaser

5.1 Mandatory information to be supplied at the time of enquiry and order

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

a) the quantity to be delivered, e.g. 2 t;

b) the shape of the product, e.g. round, hexagon, flat;

c) the dimensions and tolerances on dimensions and shape;

d) the number of this Published Document (PD 970:2005);

e) the intended application of the product and, where known, its intended end use;

f) the steel grade;

g) if ordered in accordance with the mechanical property requirements of **10.1**, the limiting ruling section required for non free cutting steels (see Table 5);

h) if ordered in accordance with the requirements of **10.2**, the condition, the size, and where appropriate, the tensile strength ranges required (see Table 7);

i) if ordered in accordance with the mechanical property requirements of Clause **11**, the ruling section and tensile strength ranges required (see Table 8);

j) if ordered in accordance with the hardenability requirements of Clauses **11** or **12**, the hardness value(s) at the required distance(s) (see Table 10 and Table 11);

k) the delivery condition of the material to be supplied (see **6.3**).

5.2 Options

A number of options are defined in this document and listed below. If the purchaser does not indicate his wish to implement one or more of these options, the supplier shall supply in accordance with the basic specification of this Published Document (see **5.1**):

a) any requirement on steelmaking process (see **6.1**);

b) any requirement on re-melted steel (see **6.1**);

c) any requirement on deoxidation (see **6.2**);

d) any requirement concerning minimum reduction ratio of rolled products (see **6.3.2**);

e) any requirement for the sulfur content if different from the standard limits (see **7.1.2**);

f) if a steel containing lead (or other element having similar effect) is required (see **7.1.3**);

g) any additional cast/product analysis (see **7.1.5**);

h) size of test bar (see **7.2.1**);

i) any special requirement on grain size and the method of measurement (see **7.3.1**);

j) any special requirement concerning determination of non-metallic inclusion content (see **7.3.2**);

k) any requirement on shearability for billets, slabs and bars;

l) any requirement for internal soundness (see **7.4**);

m) any requirements relating to surface quality, surface defects and their removal (see **7.5.1** for hot rolled products and **7.5.2** for cold finished products);

n) any requirement concerning suitability of bars, flats and rod for cold finishing (see **7.5.1.2**);

o) any requirement on surface removal for subsequent plating (see **7.5.2.2**);

p) any requirement on decarburization (see **7.6**);

q) whether Izod impact is required (see **8.2.2**);

r) location of test pieces (see **8.2.4.2**);

s) any requirement on the type of inspection document, in accordance with BS EN 10204 (see **8.5**);

t) any requirements concerning special marking of the products (see Clause **9**);

u) tolerances for semi finished product (see **13.1**);

v) whether sawn ends are required (see **14**).

6 Manufacturing process

6.1 Melting process

The primary melting process shall be via the EAF (Electric Arc Furnace) or BOS (Basic Oxygen Steelmaking) route at the steelmaker's discretion. The mixed air, open hearth and Bessemer processes shall not be used.

NOTE Steelmaking and refining may be carried out in a ladle or ladle furnace. Additional remelting processes [using VAR (Vacuum Arc Remelting) and ESR (Electro Slag Remelting)] may be specified at the time of enquiry and order.

6.2 Deoxidation

The steels covered by this Published Document (including substitutes for those traditionally produced as rimming, balanced or semi-killed) shall be killed.

NOTE They are generally produced by continuous casting, although killed ingot steels may be supplied.

Unless otherwise agreed at the time of enquiry and order, the killing technique shall be left to the discretion of the steelmaker.

6.3 Condition of material on delivery

6.3.1 *General*

Blooms, billets, slabs, black bars and rod shall be supplied as rolled or as forged unless otherwise agreed at the time of enquiry and order.

Cold finished bars shall be supplied in the condition stated on the order.

Normalized or quenched and tempered bars, including those that are subsequently cold drawn, shall be supplied to the specified mechanical properties and in the condition stated in the order.

NOTE Material used in the non heat treated condition may be supplied to Brinell hardness values, by agreement at the time of enquiry and order.

6.3.2 *Reduction ratio*

Where central soundness in the end product is important, the supplier shall make the purchaser aware in writing that a minimum reduction ratio of 4:1 from the cast product (based on cross-sectional area) is required.

NOTE For hot rolled or forged bar products a minimum reduction ratio can be agreed.

6.4 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 Table 6, Table 9 and Table 13. Where applicable, a suitable quenchant shall be used and the quench media reported to the purchaser.

7 Requirements

7.1 Chemical composition

7.1.1 *Composition ranges*

The chemical composition of the steel, based on cast analysis, shall conform to the requirements of the appropriate material specification as given in the relevant tables:

— Table 5: Hot rolled or normalized or softened steels;

— Table 7: Cold finished bar;

— Table 8: Quenched and tempered steels including nitriding grades;

— Table 10: 708H37;

— Table 11: Case hardening alloy steels with hardenability requirements;

— Table 12: Case hardening carbon manganese and low alloy steels with mechanical property requirements.

7.1.2 *Sulfur and phosphorus contents*

Carbon, carbon manganese and low alloy steels shall be supplied with sulfur and phosphorus contents of 0.035 % maximum unless otherwise specified at the time of enquiry and order [see **5.2**e)].

NOTE 1 If specified at the time of enquiry and order, a sulfur range, e.g. 0.020 % to 0.040 % may be specified to improve machinability (see **7.1.3**).

NOTE 2 Where specifically ordered, a lower content of sulfur and phosphorus, with each element at 0.025 % maximum, may be supplied. This is recommended for certain alloy nitriding steels and for tensile strengths of 1 225 MPa and greater. Other limits may be agreed at the time of enquiry and order.

7.1.3 *Steels with improved machinability characteristics*

Steels containing lead may be supplied by agreement between the purchaser and the supplier at the time of enquiry and order. Where leaded steels are to be supplied, if a specific lead range is not requested by the purchaser the lead content shall be not less than 0.12 % and not greater than 0.35 % on the cast analysis, and shall be evenly and finely distributed.

The supplier shall ensure that the addition of any other elements such as calcium, bismuth, selenium and tellurium, which may be added to improve machinability properties of certain steels, is agreed at the time of enquiry and order.

7.1.4 *Residual elements*

Elements not specified in the specification(s) called up by the order 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.

In carbon, carbon manganese and alloy steels, the following maxima shall be considered as incidental: chromium (Cr) 0.40 %, nickel (Ni) 0.40 %, copper (Cu) 0.40 %, molybdenum (Mo) 0.10 %.

NOTE In addition, at the time of enquiry and order, a limit can be agreed on the maximum combination of copper and tin. For example, the percentage of copper plus ten times the percentage of tin to be a maximum of 0.60.

7.1.5 *Product analysis*

The permissible deviations in the product analysis in relation to the specified limits for cast analysis shall be as specified in Table 1.

NOTE The purchaser can specify at the time of enquiry and order that the chemical composition on product analysis needs to be verified.

Table 1 — Permitted variations of product analysis from specified range

Element	Permissible maximum content in the cast analysis	Permissible deviation[a]
C	≤0.30	±0.02
	>0.30, ≤0.50	±0.03
	>0.50, ≤1.05	±0.04
Si	≤0.40	±0.03
Mn	≤1.00	±0.04
	>1.00, ≤1.70	±0.06
P	≤0.025	±0.005
	>0.025, ≤0.040	±0.006
	>0.040, ≤0.060	±0.008
S	≤0.025	±0.005
	>0.025, ≤0.040	±0.006
	>0.040, ≤0.060	±0.008
	>0.060, ≤0.10	±0.010
	>0.10, ≤0.30	±0.03
Cr	≤2.00	±0.05
	>2.00, ≤3.50	±0.10
Mo	≤0.30	±0.03
	>0.30, ≤0.65	±0.04
Ni	≤2.00	±0.05
	>2.00, ≤5.00	±0.07

[a] "±" means that in one cast the deviation may occur over the upper value or under the lower value of the specified ranges but not both at the same time.

7.2 Mechanical properties

7.2.1 *General*

For through hardened steels, the mechanical properties attainable from any steel composition and heat treatment shall be dependent on the ruling section.

The individual steel specifications of this Published Document 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 required properties in the appropriate ruling section at the time of heat treatment.

Because of the effect of section size, the properties for carbon and carbon manganese case-hardening steels are given for different test bar sizes in the oil-quenched condition, i.e. 13 mm, 19 mm and 29 mm, however the 19 mm size shall be used except by agreement.

When "M" grade steels are ordered, the properties given shall be for a test bar of 19 mm.

NOTE 1 It is customary to test steel to specified mechanical properties using a standard size of test bar.

NOTE 2 For alloy case hardening steels, verification of hardenability can be provided by calculation or by testing at the supplier's discretion. Hardenability bands for these steels are included in Clause **12**. These hardenability bands may be used as a guide to estimate the tensile strength of a ruling section at the time of heat treatment.

NOTE 3 All the specified mechanical properties in this Published Document refer to tests taken in the longitudinal direction.

7.2.2 *Reference symbols for tensile strength ranges of quenched and tempered material*

The various tensile ranges for the different specifications shall be designated with the reference symbols P to Z, as given in Table 2.

Table 2 — Reference symbols for tensile strength ranges of hardened and tempered material

Reference symbol	Tensile strength MPa
P	550 to 700
Q	625 to 775
R	700 to 850
S	775 to 925
T	850 to 1 000
U	925 to 1 075
V	1 000 to 1 150
W	1 075 to 1 225
X	1 150 to 1 300
Y	1 225 to 1 375
Z	1 550 minimum
NOTE 1 This method of specifying tensile strength is different to that used in all European Standards where properties for different section thicknesses are specified. NOTE 2 It is important to note that these letters should not be confused with the letters used in European steel designations as given in BS EN 10027-1.	

7.3 Technological properties

7.3.1 *Structure and grain size*

Steels shall be supplied either coarse or fine grained at the supplier's discretion unless agreed otherwise at the time of enquiry and order.

NOTE Fine grained steels are normally produced by aluminium (Al) treatment though other methods may be used.

The hardenability (for H grades) and impact toughness (where specified for M grades) specified in this document shall apply only to aluminium treated fine grained steels.

If a coarse grained steel is required, any associated hardenability, toughness or impact property requirements shall be agreed separately.

Case carburizing steels shall be supplied fine grained (aluminium treated) unless specifically ordered otherwise.

Aluminium treated steels shall be considered fine grained if the total Al content is 0.015 % or greater. However, in cases of dispute, or when specifically requested, the grain size shall be measured in accordance with BS EN ISO 643.

7.3.2 *Cleanliness*

If required, specifications for the degree of freedom from non-metallic inclusions and their methods of determination shall be agreed between the purchaser and supplier in writing at the time of enquiry and order.

7.4 Internal soundness

Requirements for internal soundness shall be agreed between the purchaser and supplier in writing at the time of enquiry and order.

7.5 Surface finish and quality

7.5.1 *Hot rolled products*

7.5.1.1 *Surface finish*

All products shall have a finish appropriate to the manufacturing processes applied.

NOTE Minor surface imperfections, which may occur under normal manufacturing conditions, may be present.

7.5.1.2 *Surface quality*

Where appropriate, requirements relating to the surface quality of the products shall be agreed in writing at the time of enquiry and order.

If suitability for cold finishing is required, this shall be agreed in writing at the time of enquiry and order.

The permissible defect depth, and when appropriate the method of removal, shall be agreed in writing at the time of enquiry and order.

Surface defects shall not be removed from the wrought product by scarfing or repaired by welding.

NOTE 1 Scarfing of semi-finished products may be used providing it is not deleterious to the product.

NOTE 2 It is more difficult to detect and eliminate surface discontinuities from coiled products than from cut lengths. This should be taken into account when agreements on surface quality are made.

7.5.2 ***Cold finished products***

7.5.2.1 *General*

Precision ground bars shall include bars supplied in the hot rolled and ground, cold drawn and ground or turned and ground conditions.

NOTE 1 Cold finished steel bars are processed from the hot worked, normalized or heat treated condition to achieve a bright surface with greater dimensional accuracy.

NOTE 2 Machining and/or grinding reduces or removes decarburization and also surface irregularities.

7.5.2.2 *Surface finish*

Drawn products shall have a smooth, bright surface. Products in the final heat treated condition shall be free from loose surface scale but their surface might be discoloured.

Isolated pores, pits and grooves can be present but in the case of rounds, their depth shall not exceed 50 % of the ordered tolerance class measured on the actual diameter.

NOTE For hexagons, squares and flats one cannot achieve (for manufacturing reasons) the same quality of surface finish as for rounds.

The depth of surface imperfections shall not be greater than ISO-tolerance h11 of BS EN 20286-2:1993 measured on the actual size.

Material requiring subsequent plating shall be subjected to surface removal, as agreed at the time of enquiry and order.

7.5.2.3 *Surface quality*

Since surface defects cannot be completely avoided in the manufacture of hot rolled products and since they are retained when drawing, the manufacturer shall ensure that agreements regarding surface quality shall be made.

The surface quality of the products shall be one of the classes according to Table 3 or Table 4 as appropriate.

NOTE 1 If agreed at the time of enquiry or order, crack detection can be carried out to an agreed surface quality standard.

For Table 3 or Table 4 products, if there is no agreement at the time of enquiry or order, the supplier shall deliver in accordance with surface quality Class 1.

NOTE 2 As surface defects cannot be eliminated without removal of material, it is recommended that a minimum stock removal of 2 % per side be removed.

Products in the "technically defect free by manufacture" condition shall only be available in the machined or machined and ground conditions.

7.6 Decarburization levels

Levels of decarburization and their method of measurement (e.g. BS EN ISO 3887) shall be specified by the purchaser at the time of enquiry and order.

Table 3 — Surface quality classes for cold finished products (excluding flats)

Class	Permissible defect depth[a]	Product form[b]		
		Rounds	Squares	Hexagons
1	Max. 0.3 mm for $d \leq 15$ mm Max. 0.02 d for $15 < d \leq 100$ mm	+	+	+
2	Max. 0.2 mm for $d \leq 20$ mm Max. 0.01 d for $20 < d \leq 75$ mm Max. 0.75 mm for $d > 75$ mm	+	+[c]	+[c]
3	Technically defect free by manufacture	+[d]	+[d]	–

[a] d is the nominal diameter of bar or distance across flats for squares and hexagons.
[b] "+" indicates available in these classes; "–" indicates not available in these classes.
[c] Eddy current crack detection is not possible for all sizes in this class.
[d] Material normally produced by surface removal.

Table 4 — Surface quality classes for cold finished flat bars examined by visual inspection

Class 1		Class 2	
Wider or flat face	Narrower or edge face	Wider or flat face	Narrower or edge face
Maximum defect depth 0.2 mm on thicknesses up to and including 20 mm, then 1.0 % on thicknesses over 20 mm.	Maximum defect depth 1.0 % of ordered width.	Maximum defect depth 0.15 mm on thicknesses up to and including 20 mm, then 0.75 % on thicknesses over 20 mm.	Maximum defect depth 0.75 % of ordered width.

8 Inspection and testing

8.1 Tensile strength of 1 225 MPa or greater

Where the tensile strength of alloy steel is specified as 1 225 MPa minimum or higher (e.g. conditions Y or Z), the test bar shall be machined to test piece size, plus a grinding allowance if required, before heat treatment. In such cases, the properties obtained shall be representative of those parts that are heat treated in the same ruling section as that of the test piece, and shall not represent larger ruling sections.

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

8.2.1 *Material not supplied in the finally heat treated condition*

Where the ruling section of the material does not differ appreciably from that of the parts to be produced, test samples shall be taken directly from the material and heat treated in the original size. Alternatively, when it is considered either by the purchaser or supplier that the results of heat treating in the original size would not be representative of the properties that would be obtained on the 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 parts at the time of heat treatment.

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

8.2.2 *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.

One tensile test and, where relevant, three Charpy 2 mm V-notch impact tests shall be taken from each batch of bars of similar size from the same cast and heat treated together, when applicable.

NOTE The Izod impact test may be used instead of the Charpy V-notch test.

8.2.3 *Steels for case hardening*

8.2.3.1 *Size of test bar*

The test bar size for all apart from carbon and carbon manganese steels shall be 19 mm in diameter.

NOTE For carbon and carbon manganese steels the standard test bar size is 19 mm but 13 mm or 29 mm diameter test bars may be used by agreement.

8.2.3.2 *Selection of samples*

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 1 The properties specified in Clause **12** 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 might be obtained.

NOTE 2 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 might be necessary to use an alloy steel for acceptable case hardenability of the largest section sizes.

8.2.3.3 *Heat treatment of test bars*

8.2.3.3.1 *Carbon and carbon manganese steels*

Carbon and carbon manganese steel test bars shall be blank carburized for at least one hour at the hardening temperature given in Table 13, (900 °C to 930 °C) and quenched in a suitable quenchant.

8.2.3.3.2 *Alloy steels*

Alloy steel test bars shall be blank carburized for at least one hour 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 13, and quenched in a suitable quenchant.

8.2.4 *Location of test pieces for mechanical testing*

8.2.4.1 *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.

8.2.4.2 *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 at the time of enquiry and order.

8.3 Frequency of other tests

8.3.1 *Number of hardness tests*

The supplier shall carry out a minimum of one test per rolled or heat treated batch in accordance with the relevant clauses of this Published Document.

NOTE The supplier should carry out sufficient testing to ensure that material conforms to the specified hardness.

8.3.2 *Number of hardenability tests*

If testing is required, one test sample representing the full cross-section of the material shall be selected to represent each cast. This shall be reduced by forging or rolling to a size not greater than 38 mm diameter. The test bar shall also be of sufficient size to ensure the complete removal of decarburization in machining to the standard test piece of 25 mm diameter.

NOTE Unless otherwise agreed the hardenability measurements may be determined by calculation.

8.3.3 *Number of grain size tests*

When a grain controlled steel is required and verification is requested, one test sample for the determination of austenitic grain size shall be selected to represent each cast.

8.4 Test methods and test results

8.4.1 *Tensile test*

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

In cases of dispute, tensile test pieces shall be machined from blooms, billets, slabs, and bars 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 $5.65\sqrt{S_0}$ where S_0 is the original cross-sectional area in mm^2.

8.4.2 *Impact tests*

8.4.2.1 The Charpy V-notch impact test shall be carried out in accordance with BS EN 10045-1. The Izod impact test shall be carried out in accordance with BS 131-1.

8.4.2.2 The average value of the results obtained for three notches shall conform to the relevant requirements of the material specifications.

NOTE One individual value may be below the specified value, provided it is not less than 70 % of that value.

8.4.3 *Hardness tests*

The hardness test shall be carried out using one of the following methods.

a) The Brinell method in accordance with BS EN ISO 6506-1 using, where possible, a 10 mm diameter ball and an equivalent load of 3 000 kg.

b) The Vickers and Rockwell methods of hardness in accordance with BS EN ISO 6507-1 and BS EN ISO 6508-1 respectively.

NOTE 1 The Brinell method is normally used for hardness testing, but the Rockwell and Vickers methods might be more appropriate for thin sections.

NOTE 2 Considerable caution should be exercised when converting from one hardness scale to another and in cases of dispute the Brinell hardness test should be used.

8.4.4 *Hardenability tests*

Hardenability tests shall be carried out in accordance with BS EN ISO 642. The values to be verified shall be selected by the purchaser in accordance with BS EN ISO 642.

8.4.5 *Grain size test*

Metallographic grain size tests shall be carried out in accordance with the appropriate method given in BS EN ISO 643.

When tested in accordance with BS EN ISO 643 fine grained steels shall have an austenitic grain size of 5 or finer.

8.5 Types of inspection documents

Products conforming to this Published Document shall be ordered and delivered with one of the inspection documents as specified in BS EN 10204. The type of document and extent of verification of testing for properties shall be agreed upon at the time of enquiry and order.

9 Marking

The supplier shall mark the products or the bundles or boxes in a suitable way (e.g. hard stamping, painting, labelling) so that it is possible to determine the cast, the steel grade and the supplier. Any special marking requirements shall be agreed at the time of enquiry and order.

If agreed at the time of enquiry and order, bar coding shall be used in accordance with DD ENV 606.

10 Specific requirements for hot rolled or normalized or softened steels and for steels supplied as cold finished bar

10.1 Specific requirements for hot rolled or normalized or softened steels

The chemical composition and mechanical properties for these steels shall be as given in Table 5.

NOTE Table 5 brings together all these steels and separates them from other conditions of these carbon and carbon manganese steels, which can be found in later clauses.

Table 5 — Hot rolled or normalized or softened steels: chemical composition and mechanical property requirements

Steel grade designation	Chemical composition		LRS	R_m min.	R_e min.	A min.	Impact KCV min.	Impact Izod min.	HBW
	C	Mn							
	%	%	mm	MPa	MPa	%	J	ft·lb	
Carbon steels (hot rolled)									
040A04	0.08 max.	0.30 to 0.50	—	—	—	—	—	—	—
040A10	0.08 to 0.13	0.30 to 0.50	—	—	—	—	—	—	—
040A12	0.10 to 0.15	0.30 to 0.50	—	—	—	—	—	—	—
080A15	0.13 to 0.18	0.70 to 0.90	—	—	—	—	—	—	—
080A17	0.15 to 0.20	0.70 to 0.90	—	—	—	—	—	—	—
080A42	0.40 to 0.45	0.70 to 0.90	—	—	—	—	—	—	—
Carbon steels (normalized)[a]									
070M55	0.50 to 0.60	0.50 to 0.90	63	700	355	12	—	—	201 to 255
			250	600	310	13	—	—	170 to 223
080M15	0.12 to 0.18	0.60 to 1.00	63	350	175	22	—	—	109 to 163
			150	330	165	22	—	—	101 to 152
Carbon steels (softened)									
060A72	0.70 to 0.75	0.50 to 0.70	—	—	—	—	—	—	241 max.
060A78	0.75 to 0.82	0.50 to 0.70	—	—	—	—	—	—	255 max.
Carbon manganese steels (normalized)[a]									
120M36	0.32 to 0.40	1.00 to 1.40	150	590	355	15	—	—	174 to 223
			250	570	340	16	—	—	163 to 217
150M19	0.15 to 0.23	1.30 to 1.70	150	550	325	18	35	30	152 to 207
			250	510	295	17	—	—	146 to 197
150M36	0.32 to 0.40	1.30 to 1.70	150	620	385	14	—	—	179 to 229
			250	600	355	15	—	—	170 to 223

NOTE LRS = limiting ruling section, R_m = tensile stress, R_e = yield stress, A = reduction in cross-sectional area, KCV = Charpy V-notch, HBW = Brinell hardness using tungsten ball.

[a] May be supplied in the as rolled condition without mechanical properties and to analysis only.

10.2 Specific requirements for steels supplied as cold finished bar

The chemical composition, mechanical properties and normalizing temperature shall be as given in Table 6 and Table 7.

Table 6 — Normalizing requirements[a]

Steel	Normalizing temperature °C
080M15	890 to 920
070M20	880 to 910
070M26	870 to 900
080M30	860 to 890
070M55	810 to 840
120M36	840 to 870
150M19	860 to 900
150M36	840 to 870

[a] Also applicable to the steels specified in **10.2**.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a]	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[b]	HBW
									MPa	MPa	%	J	ft·lb	MPa	
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Carbon steels															
080A15	0.13 to 0.18	0.70 to 0.90	—	—	—	—	—	—	—	—	—	—	—	—	—
070M20	0.16 to 0.24	0.50 to 0.90	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 150	430	215	21	—	—	—	126 to 179
								>150 ≤ 250	400	200	21	—	—	—	116 to 170
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	≥ 6 ≤ 13	560	440	10	—	—	420	—
								> 13 ≤ 16	530	420	12	—	—	390	—
								> 16 ≤ 40	490	370	12	—	—	340	—
								> 40 ≤ 63	480	355	13	—	—	290	—
								> 63 ≤ 76	450	325	14	—	—	280	—
070M26	0.22 to 0.30	0.50 to 0.90	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 63	490	245	20	—	—	—	143 to 192
								> 63 ≤ 250	430	215	20	—	—	—	126 to 179
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	≥ 6 ≤ 13	590	465	9	—	—	440	—
								> 13 ≤ 16	570	440	11	—	—	420	—
								> 16 ≤ 40	540	400	12	—	—	380	—
								> 40 ≤ 63	530	385	12	—	—	330	—
								> 63 ≤ 76	490	355	13	—	—	310	—
080M30	0.26 to 0.34	0.60 to 1.00	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 150	490	245	20	—	—	—	143 to 192
								> 150 ≤ 250	460	230	19	—	—	—	134 to 183
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	≥ 6 ≤ 13	620	480	9	—	—	460	—
								> 13 ≤ 16	600	470	10	—	—	450	—
								> 16 ≤ 40	570	430	11	—	—	400	—
								> 40 ≤ 63	560	415	12	—	—	345	—
								> 63 ≤ 76	530	385	12	—	—	320	—

NOTE LRS = limiting ruling section, R_m = tensile stress, R_e = yield stress, A = reduction in cross-sectional area, KCV = Charpy V-notch, $R_{p0.2}$ = 0.2 % proof stress; HBW = Brinell hardness using tungsten ball.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a]	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[b]	HBW
									MPa	MPa	%	J	ft·lb	MPa	
Designation	C	Mn	Cr	Mo	Ni	Others									
Carbon steels (*continued*)															
080M30	0.26 to 0.34	0.60 to 1.00	—	—	—	—	Hardened and tempered + turned or ground	P ≥ 6 ≤ 63	550 to 700	340	18	28	25	310	152 to 207
								Q ≥ 6 ≤ 19	625 to 775	415	16	28	25	400	179 to 229
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P ≥ 6 ≤ 63	550 to 700	385	13	28	25	340	152 to 207
								Q ≥ 6 ≤ 19	625 to 775	460	12	28	25	430	179 to 229
070M55	0.50 to 0.60	0.50 to 0.90	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 63	700	355	12	—	—	—	201 to 255
								> 63 ≤ 250	600	310	13	—	—	—	170 to 223
							Normalized + cold drawn or normalized + cold drawn + ground	≥ 6 ≤ 13	760	610	6	—	—	570	—
								> 13 ≤ 16	750	600	7	—	—	560	—
								> 16 ≤ 40	710	575	7	—	—	495	—
								> 40 ≤ 63	700	545	8	—	—	440	—
								> 63 ≤ 76	670	530	9	—	—	420	—
							Hardened and tempered + turned or ground	R > 13 ≤ 100	700 to 850	415	14	—	—	385	201 to 255
								S ≥ 6 ≤ 63	775 to 925	480	14	—	—	450	223 to 277
								T ≥ 6 ≤ 19	850 to 1 000	570	12	—	—	555	248 to 302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 29 ≤ 100	700 to 850	475	10	—	—	435	201 to 255
								R > 13 ≤ 29	700 to 850	510	10	—	—	475	201 to 255
								S ≥ 6 ≤ 63	775 to 925	525	10	—	—	485	223 to 277
								T ≥ 6 ≤ 19	850 to 1 000	595	9	—	—	550	248 to 302
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	201 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a]	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[b]	HBW
									MPa	MPa	%	J	ft·lb	MPa	
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Carbon manganese steels[c]															
120M36	0.32 to 0.40	1.00 to 1.40	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 150	590	355	15	—	—	—	174 to 223
								> 150 ≤ 250	570	340	16	—	—	—	163 to 217
							Hot rolled + cold drawn or hot rolled + cold drawn + ground	≥ 6 ≤ 13	710	565	6	—	—	530	—
								> 13 ≤ 16	690	555	7	—	—	510	—
								> 16 ≤ 40	660	525	8	—	—	460	—
								> 40 ≤ 63	650	510	9	—	—	400	—
								> 63 ≤ 76	620	480	9	—	—	380	—
							Hardened and tempered + turned and ground	Q ≥ 6 ≤ 100	625 to 775	415	18	35	30	385	179 to 229
								R ≥ 6 ≤ 29	700 to 850	510	16	28	25	480	201 to 255
								S ≥ 6 ≤ 19	775 to 925	570	14	28	25	555	223 to 277
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q > 13 ≤ 100	625 to 775	440	13	35	30	400	179 to 229
								R ≥ 6 ≤ 29	700 to 850	520	12	28	25	450	201 to 255
								S ≥ 6 ≤ 19	775 to 925	580	10	28	25	510	223 to 277
150M19	0.15 to 0.23	1.30 to 1.70	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 150	550	325	18	35	30	—	152 to 207
								> 150 ≤ 250	510	295	17	—	—	—	146 to 197
							Hardened and tempered + turned or ground	P > 13 ≤ 150	550 to 700	340	18	50	40	325	152 to 207
								Q ≥ 6 ≤ 63	625 to 775	430	16	50	40	415	179 to 229
								R ≥ 6 ≤ 29	700 to 850	510	16	35	30	495	201 to 255
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P > 19 ≤ 150	550 to 700	360	13	50	40	345	152 to 207
								Q ≥ 6 ≤ 63	625 to 775	450	12	50	40	435	179 to 229
								R ≥ 6 ≤ 29	700 to 850	520	12	35	30	510	201 to 255

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.
[c] May be supplied in the as-rolled and cold finished condition without mechanical properties and to analysis only.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a]	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[b]	HBW
									MPa	MPa	%	J	ft·lb	MPa	
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Carbon manganese steels[c] (*continued*)															
150M36	0.32 to 0.40	1.30 to 1.70	—	—	—	—	Normalized + turned or ground	≥ 6 ≤ 150	620	385	14	—	—	—	179 to 229
								> 150 ≤ 250	600	355	15	—	—	—	170 to 223
							Hardened and tempered + turned or ground	Q > 19 ≤ 150	625 to 775	400	18	42	35	370	179 to 229
								R > 13 ≤ 63	700 to 850	480	16	35	30	450	201 to 255
								S ≥ 6 ≤ 29	775 to 925	555	14	35	30	525	223 to 277
								T ≥ 6 ≤ 13	850 to 1 000	635	12	28	25	620	248 to 302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q > 19 ≤ 150	625 to 775	440	13	42	35	400	179 to 229
								R > 13 ≤ 63	700 to 850	520	12	35	30	480	201 to 255
								S ≥ 6 ≤ 29	775 to 925	580	10	35	30	540	223 to 277
								T ≥ 6 ≤ 13	850 to 1 000	665	9	28	25	635	248 to 302
Alloy steels															
605M36	0.32 to 0.40	1.30 to 1.70	—	0.22 to 0.32	—	—	Hardened and tempered + turned or ground	R > 150 ≤ 250	700 to 850	495	15	28	25	480	201 to 255
								R > 29 ≤ 150	700 to 850	525	17	50	40	510	201 to 255
								S > 13 ≤ 100	775 to 925	585	15	50	40	570	223 to 277
								T ≥ 6 ≤ 63	850 to 1 000	680	13	50	40	665	248 to 302
								U ≥ 6 ≤ 29	925 to 1 075	755	12	42	35	740	269 to 331
								V ≥ 6 ≤ 19	1 000 to 1 150	850	12	42	35	835	293 to 352

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.
[c] May be supplied in the as-rolled and cold finished condition without mechanical properties and to analysis only.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a]	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[b]	HBW
									MPa	MPa	%	J	ft·lb	MPa	
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Alloy steels (*continued*)															
605M36	0.32 to 0.40	1.30 to 1.70	—	0.22 to 0.32	—	—	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 29 ≤ 150	700 to 850	540	12	50	40	525	201 to 255
								S > 13 ≤ 100	775 to 925	600	11	50	40	585	223 to 277
								T ≥ 6 ≤ 63	850 to 1 000	700	9	50	40	680	248 to 302
								U ≥ 6 ≤ 29	925 to 1 075	770	9	42	35	755	269 to 331
								V ≥ 6 ≤ 19	1 000 to 1 150	865	9	42	35	850	293 to 352
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	241 max.
606M36	0.32 to 0.40	1.30 to 1.70	—	0.22 to 0.32	—	P 0.060 max. S 0.15 to 0.25	Hardened and tempered + turned or ground	R > 13 ≤ 100	700 to 850	525	15	50	40	510	201 to 255
								S ≥ 6 ≤ 63	775 to 925	585	13	42	35	570	223 to 277
								T ≥ 6 ≤ 29	850 to 1 000	680	11	35	30	665	248 to 302
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 29 ≤ 100	700 to 850	540	11	42	35	525	201 to 255
								S ≥ 6 ≤ 63	775 to 925	600	10	42	35	585	223 to 277
								T ≥ 6 ≤ 29	850 to 1 000	700	8	35	30	680	248 to 302
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	229 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a] MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[b] MPa	HBW
Designation	C	Mn	Cr	Mo	Ni	Others									
Alloy steels (*continued*)															
708M40	0.36 to 0.44	0.70 to 1.00	0.90 to 1.20	0.15 to 0.25	—	—	Hardened and tempered + turned or ground	R > 150 ≤ 250	700 to 850	495	15	28	25	480	201 to 255
								R > 63 ≤ 150	700 to 850	525	17	50	40	510	201 to 255
								S > 29 ≤ 100	775 to 925	585	15	50	40	570	223 to 277
								T ≥ 6 ≤ 63	850 to 1 000	680	13	50	40	665	248 to 302
								U ≥ 6 ≤ 29	925 to 1 075	755	12	42	35	740	269 to 331
								V ≥ 6 ≤ 19	1 000 to 1 150	850	12	42	35	835	293 to 352
								W ≥ 6 ≤ 13[d]	1 075 to 1 225	940	12	35	30	925	311 to 375
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 63 ≤ 150	700 to 850	540	12	50	40	525	201 to 255
								S > 29 ≤ 100	775 to 925	600	11	50	40	585	223 to 277
								T ≥ 6 ≤ 63	850 to 1 000	700	9	50	40	680	248 to 302
								U ≥ 6 ≤ 29	925 to 1 075	770	9	42	35	755	269 to 331
								V ≥ 6 ≤ 19	1 000 to 1 150	865	9	42	35	850	293 to 352
								W ≥ 6 ≤ 13[d]	1 075 to 1 225	955	8	35	30	940	311 to 375
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	248 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.
[d] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a] MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[b] MPa	HBW
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Alloy steels (*continued*)															
709M40	0.36 to 0.44	0.70 to 1.00	0.90 to 1.20	0.25 to 0.35	—	—	Hardened and tempered + turned or ground	R > 100 ≤ 250	700 to 850	495	15	28	25	480	201 to 255
								S > 150 ≤ 250	775 to 925	555	13	22	20	540	223 to 277
								S > 63 ≤ 150	775 to 925	585	15	50	40	570	223 to 277
								T > 29 ≤ 100	850 to 1 000	680	13	50	40	665	248 to 302
								U > 6 ≤ 63	925 to 1 075	755	12	42	35	740	269 to 331
								V ≥ 6 ≤ 29[d]	1 000 to 1 150	850	12	42	35	835	293 to 352
								W ≥ 6 ≤ 19[d]	1 075 to 1 225	940	12	35	30	925	311 to 375
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 100 ≤ 250	700 to 850	540	11	50	40	510	201 to 255
								S > 63 ≤ 150	775 to 925	600	11	50	40	585	223 to 277
								T > 29 ≤ 100	850 to 1 000	700	9	50	40	680	248 to 302
								U > 13 ≤ 63	925 to 1 075	770	9	42	35	755	269 to 331
								V ≥ 6 ≤ 29[d]	1 000 to 1 150	865	9	42	35	850	293 to 352
								W ≥ 6 ≤ 19[d]	1 075 to 1 225	955	8	35	30	940	311 to 375
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	255 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.
[d] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a] MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[b] MPa	HBW
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Alloy steels (*continued*)															
722M24	0.20 to 0.28	0.45 to 0.70	3.00 to 3.50	0.45 to 0.65	—	—	Hardened and tempered + turned or tempered + turned or ground	T ≥ 6 ≤ 250	850 to 1 000	650	13	35	30	635	248 to 302
								T ≥ 6 ≤ 150	850 to 1 000	680	13	50	40	665	248 to 302
								U ≥ 6 ≤ 150	925 to 1 075	755	12	42	35	740	269 to 331
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	T ≥ 6 ≤ 150	850 to 1 000	700	9	50	40	680	248 to 302
								U ≥ 6 ≤ 150	925 to 1 075	770	9	42	35	755	269 to 331
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	269 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a] MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[b] MPa	HBW
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Alloy steels (*continued*)															
817M40	0.36 to 0.44	0.45 to 0.70	1.00 to 1.40	0.20 to 0.35	1.30 to 1.70	—	Hardened and tempered + turned or ground	T > 150 ≤ 250	850 to 1 000	650	13	35	30	635	248 to 302
								T > 63 ≤ 150	850 to 1 000	680	13	50	40	665	248 to 302
								U > 29 ≤ 100	925 to 1 075	755	12	42	35	740	269 to 331
								V > 13 ≤ 63	1 000 to 1 150	850	12	42	35	835	293 to 352
								W ≥ 6 ≤ 29[d]	1 075 to 1 225	940	11	35	30	925	311 to 375
								X ≥ 6 ≤ 29[d]	1 150 to 1 300	1 020	10	28	25	1 005	341 to 401
								Z ≥ 6 ≤ 29[d]	1 550 min.	1 235	5	9	8	1 125	444 min.
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	T > 63 ≤ 150	850 to 1 000	700	9	50	40	680	248 to 302
								U > 29 ≤ 100	925 to 1 075	770	9	42	35	755	269 to 331
								V > 13 ≤ 63	1 000 to 1 150	865	9	42	35	850	293 to 352
								W ≥ 6 ≤ 29[d]	1 075 to 1 225	955	8	35	30	940	311 to 375
								X ≥ 6 ≤ 29[d]	1 150 to 1 300	1 035	7	28	25	1 020	341 to 401
								Z ≥ 6 ≤ 29[d]	1 550 min.	1 250	3	9	8	1 235	444 min.
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	277 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.
[d] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

Table 7 — Steels supplied as cold finished bar: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Condition	Size (diam. or size across flats)	R_m[a]	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[b]	HBW
									MPa	MPa	%	J	ft·lb	MPa	
Designation	C	Mn	Cr	Mo	Ni	Others									
Alloy steels (*continued*)															
826M40	0.36 to 0.44	0.45 to 0.70	0.50 to 0.80	0.45 to 0.65	2.30 to 2.80	—	Hardened and tempered + turned or ground	U > 150 ≤ 250	925 to 1 075	740	12	28	25	725	269 to 331
								U > 100 ≤ 150	925 to 1 075	755	12	42	35	740	269 to 331
								V > 63 ≤ 250	1 000 to 1 150	835	12	28	25	820	293 to 352
								V > 63 ≤ 150	1 000 to 1 150	850	12	42	35	835	293 to 352
								W > 29 ≤ 250[d]	1 075 to 1 225	925	11	22	20	910	311 to 375
								W > 29 ≤ 150[d]	1 075 to 1 225	940	11	35	30	925	311 to 375
								X > 29 ≤ 150[d]	1 150 to 1 300	1 020	10	28	25	1 005	341 to 401
								Y > 29 ≤ 150[d]	1 225 to 1 375	1 095	10	28	25	1 080	363 to 429
								Z > 29 ≤ 100[d]	1 550 min.	1 235	7	11	10	1 125	444 min.
							Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	U > 100 ≤ 150	925 to 1 075	770	9	42	35	765	269 to 331
								V > 63 ≤ 150	1 000 to 1 150	865	9	42	35	850	293 to 352
								W > 29 ≤ 150[d]	1 075 to 1 225	955	8	35	30	940	311 to 375
								X > 29 ≤ 150[d]	1 150 to 1 300	1 035	7	28	25	1 020	341 to 401
								Y > 29 ≤ 150[d]	1 225 to 1 375	1 110	7	28	25	1 095	363 to 429
								Z > 29 ≤ 100[d]	1 550 min.	1 250	5	11	10	1 235	444 min.
							Softened + turned, ground or cold drawn or turned, ground or cold drawn + finally softened	—	—	—	—	—	—	—	277 max.

[a] The R_m value quoted is the minimum unless otherwise stated.
[b] This value only applies when no yield phenomenon (R_e) occurs.
[d] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

11 Specific requirements for quenched and tempered steels including steels capable of surface hardening by nitriding for special applications

Quenched and tempered steels including steels capable of surface hardening by nitriding for special applications shall have one of the specifications given in Table 8.

NOTE It includes carbon and alloy steels and separates them out from conditions specified elsewhere in this document. Other steels of this type are covered in BS EN 10085.

Table 8 — Quenched and tempered steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements

Steel grade	Chemical composition %						Heat treatment condition	LRS mm	R_m MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[a] MPa	HBW
Designation	C	Mn	Cr	Mo	Ni	Others									
Carbon manganese steels															
120M36	0.32 to 0.40	1.00 to 1.40	—	—	—	—	Q	100	625 to 775	415	18	35	30	385	179 to 229
							R	29	700 to 850	510	16	28	25	480	201 to 255
							S	19	775 to 925	570	14	28	25	555	223 to 277
150M19	0.15 to 0.23	1.30 to 1.70	—	—	—	—	P	150	550 to 700	340	18	50	40	325	152 to 207
							Q	63	625 to 775	430	16	50	40	415	179 to 229
							R	29	700 to 850	510	16	35	30	495	201 to 255
150M36	0.32 to 0.40	1.30 to 1.70	—	—	—	—	Q	150	625 to 775	400	18	42	35	370	179 to 229
							R	63	700 to 850	480	16	35	30	450	201 to 255
							S	29	775 to 925	555	14	35	30	525	223 to 277
							T[b]	13	850 to 1 000	635	12	28	25	620	248 to 302
Carbon manganese free cutting steels															
212M36	0.32 to 0.40	1.00 to 1.40	—	—	—	Si 0.25 max.	P	100	550 to 700	340	20	28	25	310	152 to 207
						P 0.060 max.	Q	63	625 to 775	400	18	28	25	370	179 to 229
						S 0.12 to 0.20	R	13	700 to 850	495	16	28	25	480	201 to 255

NOTE LRS = limiting ruling section, R_m = tensile stress, R_e = yield stress, A = reduction in cross-sectional area, KCV = Charpy V-notch, $R_{p0.2}$ = 0.2 % proof stress; HBW = Brinell hardness using tungsten ball.

[a] This value only applies when no yield phenomenon (R_e) occurs.
[b] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

Table 8 — Quenched and tempered steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Heat treatment condition	LRS mm	R_m MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[a] MPa	HBW
Designation	C	Mn	Cr	Mo	Ni	Others									
Carbon manganese free cutting steels (*continued*)															
216M44	0.40 to 0.48	1.20 to 1.50	—	—	—	P 0.060 max.	Q	150	625 to 775	400	16	22	20	370	179 to 229
						S 0.12 to 0.20	R	100	700 to 850	450	15	16	15	415	201 to 255
							S	29	775 to 925	525	14	16	15	495	223 to 277
							T	13	850 to 1 000	600	12	16	15	585	248 to 302
Alloy steels															
605M36	0.32 to 0.40	1.30 to 1.70	—	0.22 to 0.32	—	—	R	250	700 to 850	495	15	28	25	480	201 to 255
							R	150	700 to 850	525	17	50	40	510	201 to 255
							S	100	775 to 925	585	15	50	40	570	223 to 277
							T	63	850 to 1 000	680	13	50	40	665	248 to 302
							U	29	925 to 1 075	755	12	42	35	740	269 to 331
							V	19	1 000 to 1 150	850	12	42	35	835	293 to 352
606M36	0.32 to 0.40	1.30 to 1.70	—	0.22 to 0.32	—	P 0.060 max.	R	100	700 to 850	525	15	50	40	510	201 to 255
						S 0.15 to 0.25	S	63	775 to 925	585	13	42	35	570	223 to 277
						—	T	29	850 to 1 000	680	11	35	30	665	248 to 302
708H37	0.34 to 0.41	0.65 to 1.05	0.80 to 1.25	0.15 to 0.25	—	—	—	—	—	—	—	—	—	—	—
708M40	0.36 to 0.44	0.70 to 1.00	0.90 to 1.20	0.15 to 0.25	—	4 × (% P) + % Sn ≤ 0.15	Q	250	625 to 775	450	15	28	25	430	179 to 229
							Q	150	625 to 775	480	18	16	15	465	179 to 229
							R	250	700 to 850	495	15	28	25	480	201 to 255
							R	150	700 to 850	525	17	50	40	510	201 to 255
							S	100	775 to 925	585	15	50	40	570	223 to 277
							T	63	850 to 1 000	680	13	50	40	665	248 to 302

[a] This value only applies when no yield phenomenon (R_e) occurs.

Table 8 — Quenched and tempered steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Heat treatment condition	LRS	R_m	R_e min.	A min.	Impact KCV min.	Impact Izod min.	$R_{p0.2}$ min.[a]	HBW
								mm	MPa	MPa	%	J	ft·lb	MPa	
Designation	**C**	**Mn**	**Cr**	**Mo**	**Ni**	**Others**									
Alloy steels (*continued*)															
708M40	0.36 to 0.44	0.70 to 1.00	0.90 to 1.20	0.15 to 0.25	—	4 × (% P) + % Sn ≤ 0.15	U	29	925 to 1 075	755	12	42	35	740	269 to 331
							V	19	1 000 to 1 150	850	12	42	35	835	293 to 352
							W[b]	13	1 075 to 1 225	940	12	35	30	925	311 to 375
709M40	0.36 to 0.44	0.70 to 1.00	0.90 to 1.20	0.25 to 0.35	—	4 × (% P) + % Sn ≤ 0.15	R	250	700 to 850	495	15	28	25	480	201 to 355
							S	150	775 to 925	555	13	22	20	540	223 to 277
							S	100	775 to 925	585	15	50	40	570	223 to 277
							T	63	850 to 1 000	680	13	50	40	665	248 to 302
							U	29	925 to 1 075	755	12	42	35	740	269 to 331
							V	29	1 000 to 1 150	850	12	42	35	835	293 to 352
							W[b]	29	1 075 to 1 225	940	12	35	30	925	311 to 375
722M24	0.20 to 0.28	0.45 to 0.70	3.00 to 3.50	0.45 to 0.65	—	4 × (% P) + % Sn ≤ 0.12	T	250	850 to 1 000	650	13	35	30	635	248 to 302
							T	150	850 to 1 000	680	13	50	40	665	248 to 302
							U	150	925 to 1 075	755	12	42	35	740	269 to 331
817M40	0.36 to 0.44	0.45 to 0.70	1.00 to 1.40	0.20 to 0.35	1.30 to 1.70	P 0.025 max.	T	250	850 to 1 000	650	13	35	30	635	248 to 302
						S 0.025 max.	T	150	850 to 1 000	680	13	50	40	665	248 to 302
							U	100	925 to 1 075	755	12	42	35	740	269 to 331
							V	63	1 000 to 1 150	850	12	42	35	835	293 to 352
							W[b]	29	1 075 to 1 225	940	11	35	30	925	311 to 375
							X[b]	29	1 150 to 1 300	1 020	10	28	25	1 005	341 to 401
							Y[b]	29	1 225 to 1 375	1 095	10	21	18	1 080	363 to 429
							Z	29	1 550 min.	1 235	5	9	8	1 125	444 min.

[a] This value only applies when no yield phenomenon (R_e) occurs.
[b] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

Table 8 — Quenched and tempered steels including steels capable of surface hardening by nitriding: chemical composition and mechanical property requirements (*continued*)

Steel grade	Chemical composition %						Heat treatment condition	LRS mm	R_m MPa	R_e min. MPa	A min. %	Impact KCV min. J	Impact Izod min. ft·lb	$R_{p0.2}$ min.[a] MPa	HBW
Designation	C	Mn	Cr	Mo	Ni	Others									
Alloy steels (*continued*)															
826M40	0.36 to 0.44	0.45 to 0.70	0.50 to 0.80	0.45 to 0.65	2.30 to 2.80	P 0.025 max. S 0.025 max.	U	250	925 to 1 075	740	12	28	25	725	269 to 331
							U	150	925 to 1 075	755	12	42	35	740	269 to 331
							V	250	1 000 to 1 150	835	12	28	25	820	293 to 352
							V	150	1 000 to 1 150	850	12	42	35	835	293 to 352
							W[b]	250	1 075 to 1 225	925	11	22	20	910	311 to 375
							W[b]	150	1 075 to 1 225	940	11	35	30	925	311 to 375
							X[b]	150	1 150 to 1 300	1 020	10	28	25	1 005	341 to 401
							Y[b]	150	1 225 to 1 375	1 095	10	28	25	1 080	363 to 429
							Z[b]	100	1 550 min.	1 235	7	11	10	1 125	444 min.
835M30	0.26 to 0.34	0.45 to 0.70	1.10 to 1.40	0.20 to 0.35	3.90 to 4.30	P 0.025 max. S 0.025 max.	Z[b]	150	1 550 min.	1 235	7	16	15	1 125	444 min.
945M38	0.34 to 0.42	1.20 to 1.60	0.40 to 0.60	0.15 to 0.25	0.60 to 0.90	—	R	250	700 to 850	495	15	28	25	480	201 to 255
							R	150	700 to 850	525	17	50	40	510	201 to 255
							S	100	775 to 925	585	15	50	40	570	223 to 277
							T	63	850 to 1 000	680	13	50	40	665	248 to 302
							U	29	925 to 1 075	755	12	42	35	740	269 to 331
							V	29	1 000 to 1 150	850	12	42	35	835	293 to 352

[a] This value only applies when no yield phenomenon (R_e) occurs.
[b] Properties cannot always be obtained by bulk heat treatment of bar but can be achieved by the appropriate heat treatment of components.

Table 9 — Quenched and tempered steels: heat treatment and maximum hardness requirements in the softened condition

Steel grade	Heat treatment to be given to test bars and to material required in the finally heat treated condition		Requirements for hardenability test		Maximum HBW when material supplied in a softened condition	
Designation	Hardening treatment temperature °C	Tempering temperature °C	Preheat treatment temperature °C	Austenitizing temperature °C	Softened condition	Temper softened condition
Carbon steels						
070M55	810 to 840	550 to 660	No hardenability data specified		Not usually supplied in the softened condition	
080M30	860 to 890	550 to 660				
Carbon manganese steels						
120M36	840 to 870	550 to 660	No hardenability data specified		Not usually supplied in the softened condition	
150M19	860 to 890	550 to 660				
150M36	840 to 870	550 to 660				
Carbon manganese free cutting steels						
212M36	840 to 870	550 to 660	No hardenability data specified		Not usually supplied in the softened condition	
216M44	830 to 860	550 to 660				
Alloy steels						
605M36	840 to 870	500 to 680	No hardenability data specified		217	235
606M36	840 to 870	500 to 680			217	235
708H37	—	—	880 to 900	875	—	—
708M40	860 to 890	550 to 700	No hardenability data specified		217	235
709M40	860 to 890	550 to 700			235	255
722M24	880 to 910	550 to 700			241	269
817M40	820 to 850	700 max.			248	277
826M40	820 to 850	660 max.			255	277
835M30	810 to 840	200 to 280			255	277
945M38	840 to 870	550 to 680			217	235

NOTE Hardening and tempering temperature ranges for heat treating test bars and material in the finally heat treated condition are for guidance only. Temperature ranges for hardenability testing are mandatory.

Table 10 — Hardenability requirements for 708H37

Steel grade	Chemical composition %				HRC[a] at distance from quenched end mm															
					Max. or min.	1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
Designation	C	Mn	Cr	Mo																
708H37	0.34 to 0.41	0.65 to 1.05	0.80 to 1.25	0.15 to 0.25	max.	59	59	59	58	58	57	57	56	54	52	48	46	45	44	43
					min.	52	51	51	50	48	47	45	43	38	35	34	33	32	32	31

[a] Rockwell hardness (C scale) (BS EN ISO 6508-1).

12 Specific requirements for case hardening steels

The requirements for case hardening steels for both carbon manganese steels and alloy steels for special applications shall be as given in Table 11 and Table 12.

NOTE In selecting a case hardening steel for components having larger section sizes, it is essential that attention be given to the need to achieve the required surface hardness as well as the core properties. This applies particularly where core strength requirements are not high and a carbon manganese or an alloy steel at the low end of the range would give the required core strength. If water hardening is not an option because of distortion, the use of an appropriate alloy steel might be necessary to achieve satisfactory case hardness.

Table 11 — Case hardening alloy steels: chemical composition and hardenability requirements

Steel grade	Chemical composition					HRC values at distance[a] mm														
						Max. or min.	1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
Designation	C	Mn	Cr	Mo	Ni																
805H22	0.19 to 0.25	0.60 to 0.95	0.35 to 0.65	0.15 to 0.25	0.35 to 0.75	max.	50	49	46	43	38	34	32	30	27	25	25	24	24	24	—
						min.	43	39	33	28	25	22	20	—	—	—	—	—	—	—	—
820H17	0.14 to 0.20	0.60 to 0.90	0.80 to 1.20	0.10 to 0.20	1.50 to 2.00	max.	46	46	46	46	45	45	44	44	42	40	38	38	37	37	—
						min.	39	39	38	37	35	33	32	30	28	26	25	25	24	24	—
822H17	0.14 to 0.20	0.40 to 0.70	1.30 to 1.70	0.15 to 0.25	1.75 to 2.25	max.	46	46	46	46	45	45	45	45	45	44	43	43	42	42	—
						min.	39	39	39	38	38	37	37	36	35	33	32	31	30	29	—
835H15	0.12 to 0.18	0.25 to 0.50	1.00 to 1.40	0.15 to 0.30	3.90 to 4.30	max.	45	45	45	45	45	45	45	45	45	45	44	44	44	43	—
						min.	38	38	38	38	38	38	38	38	37	36	35	34	33	32	—

[a] Rockwell hardness (C scale) (BS EN ISO 6508-1).

Table 12 — Case hardening carbon manganese and low alloy steels: chemical composition and mechanical property requirements[a]

Steel grade	Chemical composition %						Test bar diameter mm	R_m min. MPa	A min. %	Impact min. KCV J	Impact min. Izod ft·lb
Designation	C	Mn	Cr	Mo	Ni	Others					
Carbon manganese steels											
130M15	0.12 to 0.18	1.10 to 1.50	—	—	—	—	13	740	13	28	25
							19	650	14	35	30
							29	590	15	42	35
214M15	0.12 to 0.18	1.20 to 1.60	—	—	—	S 0.13 to 0.18	13	740	12	28	25
							19	650	12	35	30
							29	590	13	42	35
Alloy steels											
635M15	0.12 to 0.18	0.60 to 0.90	0.40 to 0.80	—	0.70 to 1.00	—	19	770	12	22	20
655M13	0.10 to 0.16	0.35 to 0.60	0.70 to 1.00	—	3.00 to 3.75	—	19	1 000	9	35	30
665M17	0.14 to 0.20	0.35 to 0.75	—	0.20 to 0.30	1.50 to 2.00	—	19	770	12	35	30
805M22	0.19 to 0.25	0.60 to 0.95	0.35 to 0.65	0.15 to 0.25	0.35 to 0.75	—	19	930	10	11	10
805A22	0.20 to 0.25	0.70 to 0.90	0.40 to 0.60	0.15 to 0.25	0.40 to 0.70	—	—	—	—	—	—
808M17	0.14 to 0.20	0.70 to 1.05	0.35 to 0.65	0.30 to 0.40	0.35 to 0.75	—	19	930	10	22	20
822M17	0.14 to 0.20	0.40 to 0.70	1.30 to 1.70	0.15 to 0.25	1.75 to 2.25	—	19	1 310	8	22	20
835M15	0.12 to 0.18	0.25 to 0.50	1.00 to 1.40	0.15 to 0.30	3.90 to 4.30	—	19	1 310	8	28	25

[a] A suitable quenching media should be used.

Table 13 — Case hardening steels: heat treatment and maximum hardness requirements

Steel designation	Hardening temperature °C	Max. hardness HBW (when specified on the order) in the condition of delivery			
		Bars and billets for forging	Bars for machining		
			Normalized	Sub-critically annealed	Normalized and tempered
Carbon manganese steels					
130M15	900 to 930	—	—	—	—
214M15	900 to 930	—	—	—	—
Alloy steels					
635M15	820 to 840	207	207	—	—
655M13	800 to 820	255	—	255	223
665M17	820 to 840	207	207	—	—
805M22	820 to 840	217	217	—	—
820M17	820 to 840	277	—	269	248
822M17	820 to 840	277	—	269	255
835M15	800 to 820	277	—	277	269

13 Specific requirements for tolerances

13.1 Semi-finished products

Dimensional and shape tolerances for semi-finished products shall be agreed between the purchaser and supplier at the time of enquiry and order.

NOTE The UK Steel standard UKS 01, "Semi-finished steel products for the manufacture of hot rolled bar, rod and sections" specifies such tolerances.

13.2 Black bar for special applications

For special applications, tolerances shall be agreed at the time of enquiry and order.

13.3 Black bar for general applications

13.3.1 *Flats*

The dimensions and tolerances on shape and dimensions for flats (150 mm wide and below) shall be in accordance with BS EN 10058.

13.3.2 *Wide flats (151 mm to 600 mm bar mill products)*

13.3.2.1 *General*

The tolerances for wide flats given in **13.3.2.2** to **13.3.2.7** shall apply.

NOTE Tolerances for wide flats are not currently specified in any European Standard.

13.3.2.2 *Width tolerance*

The width tolerance for wide flats shall be ±2 % of the specified width but shall not exceed ±5 mm.

The width shall be measured at a distance not less than 200 mm from the end of the wide flat.

13.3.2.3 *Thickness tolerance*

The thickness tolerance for wide flats shall be as given in Table 14.

The thickness shall be measured at a distance not less than 15 mm from the longitudinal edges and not less than 200 mm from the end of the wide flat.

Table 14 — Thickness tolerances for wide flats

Specified thickness mm	Tolerances mm
> 4 < 10	±0.5
10 < 20	±0.6
20 < 25	±0.7
25 < 30	±0.8
30 < 40	±0.9
40 < 50	±1.0
50 < 60	±1.1
60 < 80	±1.3
≥ 80	±2.0

13.3.2.4 *Length tolerance*

The tolerance on the specified length shall be agreed at the time of enquiry and order.

13.3.2.5 *Squareness of edges*

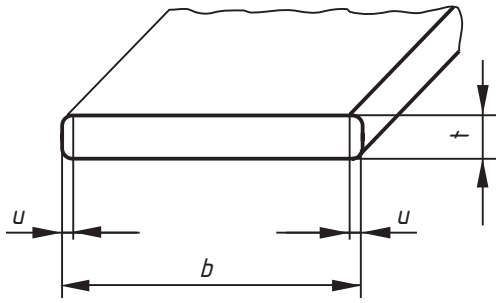
Any deviation from squareness of edges for wide flats shall be as given in Table 15. Measurements of deviation shall be made at least 200 mm from the end of the bar.

NOTE Three types of deviation from square edge are permissible and are illustrated in Figure 1:

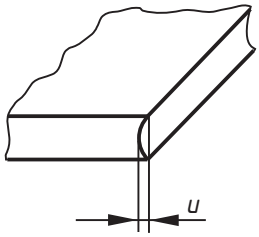
— convex edge;
— concave edge;
— rhomboid edge.

Table 15 — Deviation from squareness of edges for wide flats

Specified thickness, t mm	**Deviation,** u mm
≤ 13	2.0
> 13 ≤ 18	3.0
> 18	3.5
NOTE See Figure 1.	



a) Convex edge



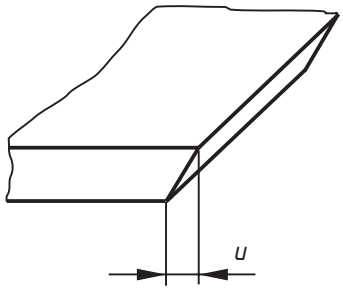
b) Concave edge

Key

t = thickness

b = overall width

u = deviation



c) Rhomboid edge

Figure 1 — Types of deviation from square

13.3.2.6 *Edge camber tolerances*

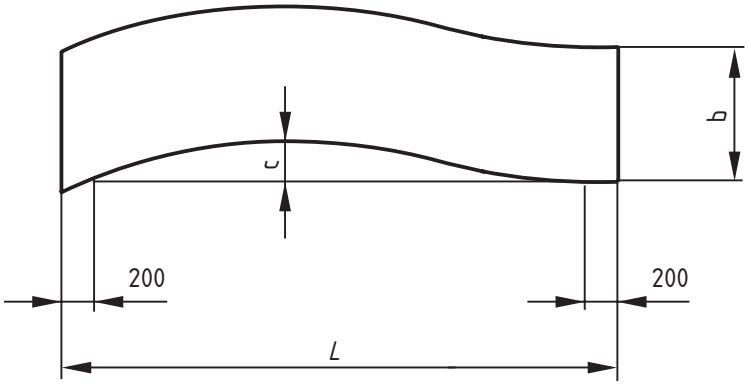
The edge camber tolerances for wide flats shall be a normal straightness edge camber not exceeding 0.25 % of the length, L, of the wide flat.

The edge camber value, c, shall be taken as the maximum deviation between one longitudinal edge and the straight line joining the two edges of this edge. It shall be measured on the concave edges of the wide flat.

NOTE See Figure 2.

The measuring points shall be at least 200 mm from the end of the wide flat.

All dimensions are in millimetres



Key
b = overall width
c = edge camber value
L = overall length

Figure 2 — Edge camber of wide flats

13.3.2.7 *Flatness tolerances*

The deviation in the transverse direction shall not exceed 0.3 % of the width of the wide flat.

The deviation in the longitudinal direction related to a straight edge length of 1 000 mm, shall not exceed 7 mm.

The measuring points shall be at least 200 mm from the end of the wide flat.

13.3.3 ***Squares***

The dimensions and tolerances on shape and dimensions shall be in accordance with BS EN 10059.

13.3.4 ***Rounds***

The dimensions and tolerances on shape and dimensions shall be in accordance with BS EN 10060.

13.3.5 ***Hexagons***

The dimensions and tolerances on shape and dimensions shall be in accordance with BS EN 10061.

13.4 Bars for cold finishing

13.4.1 *Bars*

The dimensions and tolerances on shape and dimensions for rounds, squares and hexagons shall be in accordance with Table 16. The out of section (see Table 16) shall not be above the upper limit, or below the lower limit, of the tolerance. For round bars, the out of section shall be measured as the difference between the maximum and minimum diameters on the same cross-section. For square and hexagon bars, the out of section shall be measured as the difference between parallel faces on the same cross-section.

Table 16 — Tolerances for hot rolled round, square and hexagon bars suitable for cold finishing

Size	Permitted variation	
	Diameter or width across flats	Out of section[a]
mm	mm	mm
≤ 16	0 to +0.4	0.3
> 16 ≤ 26	0 to +0.6	0.5
> 26 ≤ 38	0 to +0.8	0.6
> 38 ≤ 51	0 to +1.0	0.7
> 51 ≤ 64	0 to +1.2	0.9
> 64 ≤ 90	0 to +1.4	1.1
> 90 ≤ 160	0 to +1.6	1.2

[a] For round bars, out of section is the difference between the maximum and minimum diameter of the bar measured on the same axis of the bar. For square bars, out of section is the difference between the two dimensions measured across the two pairs of opposing (parallel) sides at the same axis of the bar. For hexagon bars, out of section is the difference between the least and greatest dimensions measured across three pairs of opposing (parallel) flats at the same axis of the bar.

13.4.2 *Flats*

The tolerance for flats for cold finishing shall be agreed at the time of order and enquiry and should take into account the drafting.

13.5 Cold finished bar

The dimensions and tolerances on shape and dimensions for cold finished bars shall be in accordance with BS EN 10278.

The thickness measurements for flats shall be taken at a point 12 mm in from the edge.

14 Cut end condition

Where end condition is critical the purchaser shall specify at the time of enquiry and order that a sawn end is required.

NOTE Shearing to length might distort the ends of all products.

Annex A (informative)
Correlation between steels from BS 970-1:1983, PD 970:2005 and current nationally adopted European Standards

Table A.1 presents the current status of all the steels originally specified in BS 970-1:1983 in terms of either their inclusion in PD 970, their equivalents in nationally adopted European Standards or their complete withdrawal from all standards.

Table A.1 — Correlation between steels from BS 970-1:1983, PD 970:2005 and current nationally adopted European Standards

Steel in BS 970-1:1983	Steel in PD 970:2005	European steel name[a]	European steel number	BS EN standard
040A04	040A04	—	—	—
040A10	040A10	—	—	—
040A12	040A12	—	—	—
045A10	—	C10E	1.1121	BS EN 10084:1998
045M10	—	C10E	1.1121	BS EN 10084:1998
055M15	—	—	—	—
060A32	—	—	—	—
060A40	—	—	—	—
060A45	—	—	—	—
060A47	—	—	—	—
060A57	—	—	—	—
060A62	—	—	—	—
060A67	—	—	—	—
060A72	060A72	—	—	—
060A78	060A78	—	—	—
060A81	—	—	—	—
070M20	070M20	C22E	1.1151	BS EN 10083-1:1991
070M26	070M26	C25E	1.1158	BS EN 10083-1:1991
070M55	070M55	C55E	1.1203	BS EN 10083-1:1991
080A15	080A15	C16E	1.1148	BS EN 10084:1998
080A17	080A17	—	—	—
080A20	—	—	—	—
080A30	—	—	—	—
080A32	—	—	—	—
080A35	—	—	—	—
080A37	—	—	—	—
080A40	—	—	—	—
080A42	080A42	—	—	—
080A47	—	—	—	—
080A52	—	—	—	—
080A57	—	—	—	—
080A67	—	—	—	—
080H36	—	C35E+H	1.1181+H	BS EN 10083-1:1991
080H41	—	C40E+H	1.1186+H	BS EN 10083-1:1991
080H46	—	C45E+H	1.1191+H	BS EN 10083-1:1991

[a] In accordance with BS EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

Table A.1 — Correlation between steels from BS 970-1:1983, PD 970:2005 and current nationally adopted European Standards (*continued*)

Steel in BS 970-1:1983	Steel in PD 970:2005	European steel name[a]	European steel number	BS EN standard
080M15	080M15	C16E	1.1148	BS EN 10084:1998
080M30	080M30	C30E	1.1178	BS EN 10083-1:1991
080M36	—	C35E	1.1181	BS EN 10083-1:1991
080M40	—	C40E	1.1186	BS EN 10083-1:1991
080M46	—	C45E	1.1191	BS EN 10083-1:1991
080M50	—	C50E	1.1206	BS EN 10083-1:1991
120M19	—	—	—	—
120M28	—	—	—	—
120M36	120M36	—	—	—
125A15	—	—	—	—
130M15	130M15	—	—	—
135M44	—	—	—	—
150M19	150M19	—	—	—
150M28	—	28Mn6	1.1170	BS EN 10083-1:1991
150M36	150M36	—	—	—
150M40	—	—	—	—
170H15	—	—	—	—
170H20	—	—	—	—
170H36	—	—	—	—
170H41	—	—	—	—
173H16	—	—	—	—
174H20	—	—	—	—
175H23	—	—	—	—
185H40	—	—	—	—
210A15	—	—	—	—
210M15	—	15SMn13	1.0725	BS EN 10087:1999
212A37	—	—	—	—
212A42	—	—	—	—
212M36	212M36	—	—	—
214A15	—	—	—	—
214M15	214M15	—	—	—
216A42	—	—	—	—
216M28	—	—	—	—
216M36	—	36SMn14	1.0764	BS EN 10087:1999
216M44	216M44	—	—	—
220M07	—	—	—	—
225M36	—	—	—	—
226M44	—	44SMn28	1.0762	BS EN 10087:1999
230M07	—	11SMn30	1.0715	BS EN 10087:1999
280M01	—	—	—	BS EN 10267:1998
302S31	—	X10CrNi18-8	1.4310	BS EN 10088-3:1995

[a] In accordance with BS EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

Table A.1 — Correlation between steels from BS 970-1:1983, PD 970:2005 and current nationally adopted European Standards (*continued*)

Steel in BS 970-1:1983	Steel in PD 970:2005	European steel name[a]	European steel number	BS EN standard
303S31	—	X8CrNiS18-9	1.4305	BS EN 10088-3:1995
303S42	—	—	—	—
304S11	—	X2CrNi18-9	1.4307	BS EN 10088-3:1995
		X2CrNi19-11	1.4306	
304S15	—	X5CrNi18-10	1.4301	BS EN 10088-3:1995
304S31	—	X5CrNi18-10	1.4301	BS EN 10088-3:1995
310S31	—	X8CrNi25-21	1.4845	BS EN 10095:1999
316S11	—	X2CrNiMo17-12-2	1.4404	BS EN 10088-3:1995
316S13	—	X2CrNiMo17-12-3	1.4432	BS EN 10088-3:1995
316S31	—	X5CrNiMo17-12-2	1.4401	BS EN 10088-3:1995
316S33	—	X3CrNiMo17-13-3	1.4436	BS EN 10088-3:1995
320S31	—	X6CrNiMoTi17-12-2	1.4571	BS EN 10088-3:1995
321S31	—	X6CrNiTi18-10	1.4541	BS EN 10088-3:1995
325S31	—	—	—	—
347S31	—	X6CrNiNb18-10	1.4550	BS EN 10088-3:1995
403S17	—	X6Cr13	1.4000	BS EN 10088-3:1995
410S21	—	X12Cr13	1.4006	BS EN 10088-3:1995
416S21	—	X12CrS13	1.4005	BS EN 10088-3:1995
416S29	—	—	—	—
416S37	—	X29CrS13	1.4029	BS EN 10088-3:1995
416S41	—	—	—	—
420S29	—	X20Cr13	1.4021	BS EN 10088-3:1995
420S37	—	X20Cr13/X30Cr13	1.4021/1.4028	BS EN 10088-3:1995
430S17	—	X6Cr17	1.4016	BS EN 10088-3:1995
431S29	—	X17CrNi16-2	1.4057	BS EN 10088-3:1995
523H15	—	—	—	—
523M15	—	—	—	—
527A17	—	17Cr3	1.7016	BS EN 10084:1998
527H17	—	17Cr3+H	1.7016+H	BS EN 10084:1998
527M17	—	17Cr3	1.7016	BS EN 10084:1998
530A30	—	—	—	—
530A32	—	—	—	—
530A36	—	—	—	—
530A40	—	—	—	—
530H32	—	34Cr4+H	1.7033+H	BS EN 10083-1:1991
530H36	—	37Cr4+H	1.7034+H	BS EN 10083-1:1991
530H40	—	41Cr4+H	1.7035+H	BS EN 10083-1:1991
530M40	—	41Cr4	1.7035	BS EN 10083-1:1991
535A99	—	—	—	—
590A15	—	16MnCr5	1.7131	BS EN 10084:1998
590H17	—	16MnCr5+H	1.7131+H	BS EN 10084:1998
590M17	—	16MnCr5	1.7131	BS EN 10084:1998
605A32	—	—	—	—
605A37	—	—	—	—

[a] In accordance with BS EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

Table A.1 — Correlation between steels from BS 970-1:1983, PD 970:2005 and current nationally adopted European Standards (*continued*)

Steel in BS 970-1:1983	Steel in PD 970:2005	European steel name[a]	European steel number	BS EN standard
605H32	—	—	—	—
605H37	—	—	—	—
605M36	605M36	—	—	—
606M36	606M36	—	—	—
635A14	—	—	—	—
635H15	—	—	—	—
635M15	635M15	—	—	—
637A16	—	—	—	—
637H17	—	16NiCr4+H	1.5714+H	BS EN 10084:1998
637M17	—	16NiCr4	1.5714	BS EN 10084:1998
655H13	—	15NiCr13+H	1.5752+H	BS EN 10084:1998
655M13	655M13	15NiCr13	1.5752	BS EN 10084:1998
665H17	—	—	—	—
665H20	—	—	—	—
665H23	—	—	—	—
665M17	665M17	—	—	—
665M20	—	—	—	—
665M23	—	—	—	—
708A25	—	—	—	—
708A30	—	—	—	—
708A37	—	—	—	—
708A40	—	—	—	—
708A42	—	—	—	—
708A47	—	—	—	—
708H20	—	—	—	—
708H37	708H37	—	—	—
708H42	—	42CrMo4+H	1.7225+H	BS EN 10083-1:1991
708H45	—	—	—	—
708M20	—	18CrMo4	1.7243	BS EN 10084:1998
708M40	708M40	42CrMo4	1.7225	BS EN 10083-1:1991
709A37	—	—	—	—
709A40	—	—	—	—
709A42	—	—	—	—
709M40	709M40	—	—	—
720M32	—	—	—	—
722M24	722M24	24CrMo13-6	1.8516	BS EN 10085:2001
805A17	—	—	—	—
805A20	—	20NiCrMo2-2	1.6523	BS EN 10084:1998
805A22	805A22	—	—	—
805H17	—	—	—	—
805H20	—	20NiCrMo2-2+H	1.6523+H	BS EN 10084:1998
805H22	805H22	—	—	—
805M17	—	—	—	—

[a] In accordance with BS EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

Table A.1 — Correlation between steels from BS 970-1:1983, PD 970:2005 and current nationally adopted European Standards (*continued*)

Steel in BS 970-1:1983	Steel in PD 970:2005	European steel name[a]	European steel number	BS EN standard
805M20	—	20NiCrMo2-2	1.6523	BS EN 10084:1998
805M22	805M22	—	—	—
808H17	—	—	—	—
808M17	808M17	—	—	—
815H17	—	17NiCrMo6-4+H	1.6566+H	BS EN 10084:1998
815M17	—	—	—	—
817A37	—	—	—	—
817A42	—	—	—	—
817M40	817M40	34CrNiMo6	1.6582	BS EN 10083-1:1991
820H17	820H17	—	—	—
820M17	—	—	—	—
822H17	822H17	—	—	—
822M17	822M17	—	—	—
823H13	—	—	—	—
826M31	—	—	—	—
826M40	826M40	—	—	—
832H13	—	14NiCrMo13-4+H	1.6657+H	BS EN 10084:1998
832M13	—	—	—	—
835H15	835H15	—	—	—
835M15	835M15	—	—	—
835M30	835M30	30NiCrMo16-6	1.6747	—
897M39	—	40CrMoV13-9	1.8523	BS EN 10085:2001
905M39	—	41CrAlMo7-10	1.8509	BS EN 10085:2001
945M38	945M38	—	—	—

[a] In accordance with BS EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

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