British Standard

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John May

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BRITISH STANDARD

BS 970-3:1991

Incorporating Amendment Nos. 1 and 2

Specification for

Wrought steel for mechanical and allied engineering purposes —

Part 3: Bright bars for general engineering purposes

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) to Technical Committee ISM/31, upon which the following bodies were represented:

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

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Contents

Foreword

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 It supersedes those clauses concerned with bright finished bars in BS 970-1:1983, which is withdrawn.

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Committee ISM/31 has decided that requirements for bars supplied in the bright cold finished condition should be withdrawn from BS 970-1:1983 to appear in a separate standard for the sake of clarity and as a preparatory step towards a European Standard for this product range.

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

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 30, an inside back cover and a back cover.

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

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1 Scope

This Part of BS 970 specifies requirements for carbon and carbon manganese, alloy, free-cutting and stainless steels normally supplied in the bright cold finished condition. It is only applicable to steels supplied in straight lengths.

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

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

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

2 Definitions and symbols

2.1 Definitions

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

2.1.1
bright cold drawn bars

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

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

2.1.2
bright turned bars

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

2.1.3
precision ground bars

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

2.1.4
annealing

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

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

2.1.5
normalizing

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

2.1.6
stress relieving

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

2.1.7
hardening and tempering

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

2.1.8
ruling section

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

2.1.9
limiting ruling section

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

2.1.10
equivalent diameter

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

2.1.11
test sample

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

2.1.12
test piece

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

2.2
symbols

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

3 Information and requirements to be agreed and to be documented

3.1 Information to be supplied by the purchaser

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

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

a) details of the form of section, size, length and quantity;

b) the tolerances required on sections (see Table 1 to Table 4);

c) the grade of steel required (see Table 5 and Table 6 and Table 12 to Table 28);

d) the tolerances required on length;

e) surface condition of supply (see clause **12** and Table 7 to Table 11);

f) heat treatment condition together with any physical properties required (see Table 19 to Table 28);

3.2 Options

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

3.3 Items for agreement

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

a) If controlled magnetic properties are required they shall be agreed at the time of enquiry and/or order (see **4.3.2**).

b) If bars shall be supplied with special corrosion protection it shall be specified and agreed at the time of enquiry and/or order (see **4.6**).

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

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

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

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

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

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

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

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

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

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

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

4 General

4.1 Steel products

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

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

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

4.3 Stainless steels

4.3.1 *Ferritic steels*

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

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

4.3.2 *Austenitic steels*

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

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

4.3.3 *Martensitic steels*

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

4.4 Specific requirements of Table 12 to Table 28

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

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

b) specified mechanical properties (M grades);

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

c) specified hardenability properties (H grades).

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

4.5 Cast analysis

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

4.6 Corrosion protection

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

5 Steelmaking process and casting methods

5.1 Steelmaking

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

5.2 Casting method

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

NOTE For the purposes of Table 7 steel 230M07 is supplied as a balanced quality. The other steels listed in Table 12 are supplied as killed free-cutting qualities.
Steels listed in Table 13 are supplied as killed carbon steels.
Steels listed in Table 14 are supplied as killed carbon or killed coarse grain steels depending upon ordered requirements. Steels in Table 15 and Table 16 are classified as low alloy steels.

6 Dimensional tolerances

6.1 Sectional tolerances

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

Table 1 — Tolerances for cold drawn bar

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

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

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

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

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

Table 2 — Tolerances for turned bars

Size, diameter	Permitted variation
mm	mm
≥ 6 ≤ 18	+ 0 to – 0.070
> 18 ≤ 30	+ 0 to – 0.085
> 30 ≤ 50	+ 0 to – 0.100
> 50 ≤ 80	+ 0 to – 0.120
> 80 ≤ 120	+ 0 to – 0.140
> 120 ≤ 180	+ 0 to – 0.160
> 180 ≤ 250	+ 0 to – 0.185
> 250 ≤ 315	+ 0 to – 0.210
> 315 ≤ 400	+ 0 to – 0.230
> 400	+ 0 to – 0.250

6.2 Tolerances for precision ground bars

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

Table 3 — Tolerances for precision ground bars

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

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

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

6.3 Straightness tolerance

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

Table 4 — Straightness tolerances

Section	Steel grade	Permitted variation
Rounds	< 0.25 % carbon	1 in 1 000
	≥ 0.25 % carbon, alloys and all heat treated grades	1 in 500
Squares and hexagons	< 0.25 % carbon ≤ 75 mm	1 in 750
	< 0.25 % carbon > 75 mm	1 in 500
	≥ 0.25 % carbon, alloys and all heat treated grades	1 in 375
Flats	< 0.25 % carbon	1 in 500
	≥ 0.25 % carbon, alloys and all heat treated grades	1 in 375

6.4 Special tolerances

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

7 Selection and preparation of test samples

7.1 Selection of test samples

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

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

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

7.2 Steel of tensile strength of 1 225 N/mm^2 or greater

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

7.3 Steels for case hardening

7.3.1 *Size of test sample*

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

7.3.2 *Selection of samples*

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

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

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

7.3.3 *Heat treatment of test piece*

7.3.3.1 *Carbon and carbon manganese steels*

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

7.3.3.2 *Alloy steels*

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

7.4 Location of test pieces for mechanical testing

7.4.1 *General*

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

a) For ruling sections up to and including 25 mm, the test piece shall be machined coaxially from the test bars.

b) For ruling sections over 25 mm, the longitudinal axis of the test piece shall be 12.5 mm from the surface of the test bars.

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

7.4.2 *Transverse and other tests*

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

7.5 Frequency of other tests

7.5.1 *Number of hardness tests*

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

7.5.2 *Number of hardenability tests*

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

8 Test methods and test results

8.1 Tensile test

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

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

8.1.3 In cases of dispute tensile test pieces shall be machined from bars to the dimensions of the 11.28 mm diameter (100 mm^2 cross-sectional area) test piece or, if the test sample is too small, to the dimensions of the largest recommended round test piece that can be obtained having a gauge length equal to $5.65\sqrt{S_O}$.

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

8.2 Impact test

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

8.3 Hardness test

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

8.4 Hardenability test

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

8.5 Grain size test

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

8.6 Intercrystalline corrosion test

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

9 Chemical composition

9.1 Composition ranges

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

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

9.2 Residual elements

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

Table 5 — Maximum limits on residual elements

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

9.3 Lead bearing steels

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

9.4 Product analysis and permitted deviations

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

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

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

10 Mechanical properties

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

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

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

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

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

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

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

Table 6 — Permitted variations of product analysis from specified range

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

Table 6 — Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element falls	Variation on specified range	
		over max.	under min.
	%(m/m)	%(m/m)	%(m/m)
(b) Alloy steels and alloy free cutting 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 ≤ 1.00	0.04	0.04
	> 1.00 ≤ 2.00	0.05	0.05
Phosphorus	≤ 0.030	0.003	
	> 0.030 ≤ 0.040	0.004	
Sulfur	≤ 0.030	0.003	
	> 0.030 ≤ 0.040	0.004	
	> 0.040 ≤ 0.050	0.005	
	> 0.10 ≤ 0.20	0.025	0.025
	> 0.20 ≤ 0.40	0.04	0.04
	When range is specified		
	0.015 to 0.040	0.004	0.003
	0.025 to 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
Lead	0.15 to 0.35	0.03	0.02

Table 6 — Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element falls	Variation on specified range	
		over max.	under min.
	%(m/m)	%(m/m)	%(m/m)
(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	
Sulfur	≤ 0.030	0.003	
	> 0.030 ≤ 0.080	0.005	
	Specified range		
	0.15 to 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

[a] 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.

10.4 The 19 mm test piece size shall be used. (See also **3.3** e).)

NOTE 1 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 piece. However, because of the effect of section size, the properties are quoted for different test piece sizes in the oil-quenched condition, i.e. 13 mm, 19 mm and 29 mm, but the 19 mm test piece is to be used unless otherwise agreed.

NOTE 2 The properties specified for both carbon and alloy steels apply only to the test piece size used and the heat treatment specified. If other heat treatments and/or sizes of test piece are used, then different results may be obtained. The conditions for these heat treatments and tests should be agreed between the purchaser and the supplier.

NOTE 3 The properties obtained are representative of those bars heat treated in the same ruling section as that of the test piece and may not represent larger ruling sections.

11 Retests

11.1 General

Retests shall be carried out as specified in **11.2** to **11.4**. If any test sample or test piece fails to comply with the specified requirements as a result of incorrect application of the test procedure or faulty equipment, the test results shall be discarded and a further test sample(s) shall be retested.

11.2 Tensile tests

11.2.1 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 from which the original test sample was taken, unless that item has been withdrawn by the manufacturer.

11.2.2 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 this standard.

11.2.3 In the case of material supplied in the heat treated condition, the manufacturer shall have the right to re-heat treat the material and resubmit it for retesting.

11.2.4 In the case of dispute with the reported yield stress the 0.5 % proof stress (total elongation) shall be used.

11.3 Impact test

11.3.1 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 shall be lower than the specified value and not more than one shall be lower than 70 % of this value.

11.3.2 In the case of material supplied in the heat treated condition, the manufacturer shall have the right to re-heat treat the material and resubmit it for retesting.

11.4 Hardness test

11.4.1 Should the hardness value determined on any bar fail to comply with the specified requirements, then three additional test samples of items shall be selected for retesting, one of which shall be from the original bar unless that item has been withdrawn by the manufacturer.

12 Freedom from defects

12.1 Internal soundness

The procedures for casting, hot-working, re-heating and cooling shall ensure that the product is free from piping, central unsoundness and harmful segregation.

NOTE Where assurance is required see also **3.3** j).

12.2 Cleanness

If specific levels of cleanness are required, they shall be in accordance with the standards specified in the enquiry and/or order, see **3.3** k).

NOTE Sulfide inclusions and segregation lines which are intrinsic to free-cutting steels are not to be regarded as a defect in the material.

12.3 Surface condition

12.3.1 *Cold drawn bar and cold drawn and ground bar*

12.3.1.1 Surface defects shall not exceed the maximum values given in Table 7 to Table 11, in bars supplied in the cold drawn and cold drawn and ground condition.

Table 7 — Rounds, squares and hexagons in sizes from 10 mm up to and including 100 mm diameter or across flat: maximum permissible surface defects

Steel type	Maximum permissible defect depth as percentage of section
	%
Balanced free-cutting	2.00
Killed free-cutting	1.25
Killed carbon	1.00
Killed coarse grain	2.00
Hot or cold forging	0.75
Low alloy and stainless	0.75

12.3.1.2 The minimum rejectable defect depth for balanced free-cutting, killed free-cutting, killed carbon and killed coarse grain steels shall be 0.25 mm irrespective of section, and for hot or cold forging and low alloy and stainless steels it shall be 0.20 mm.

Table 8 — Flats greater than 105 mm wide in free-cutting, semi-free-cutting and carbon steels: maximum permissible surface defects

Thickness	Maximum permissible defect depth on the wider or flat faces	
	Widths > 105 mm to ≤ 160 mm	Widths > 160 mm
mm	mm	mm
> 3 ≤ 10	0.20	0.20
> 10 ≤ 18	0.25	0.25
> 18 ≤ 30	0.30	0.45
> 30 ≤ 50	0.50	0.80
> 50 ≤ 80	0.70	1.00
> 80 ≤ 105	0.80	1.00
> 105	1.00	1.00

12.3.1.3 The maximum permissible defect depth on the surfaces of the narrower or edge faces of flats in qualities and sizes covered by Table 8 shall be 1 mm.

Table 9 — Flats greater than 105 mm wide in hot and cold forging steels and low alloy steels: maximum permissible defect depths

Thickness	Maximum permissible defect depth on the wider or flat faces
mm	mm
> 3 ≤ 10	0.10
> 10 ≤ 18	0.15
> 18 ≤ 30	0.20
> 30 ≤ 50	0.30
> 50 ≤ 80	0.50
> 80	0.70
NOTE The defect is to be measured perpendicular to the bar surface.	

12.3.1.4 The maximum permissible defect depth on the surface of the narrower or edge face of flats in qualities and sizes covered by Table 9 shall be 0.7 min.

NOTE Where specific assurance of maximum defect levels is required materials can be supplied crack detected. (See also **3.3** j).)

12.3.2 *Turned bar and turned and ground bar*

The stock removal during the manufacture of bars to be supplied in the turned or turned and ground condition, shall be sufficient to ensure freedom from surface defects of steel making or hot rolling origin.

12.4 Decarburization

Turned or turned and ground bars shall be free from decarburization.

NOTE For bars produced by drawing see also **3.3** l).

13 Marking

Unless otherwise specified at the time of enquiry and/or order bars shall be supplied labelled but unmarked.(See **3.3** m).)

Table 10 — Flats equal to or less than 105 mm wide in free-cutting, semi-free-cutting and carbon steels: maximum permissible defect depths

Thickness	Maximum permissible defect depths				
	Wider or flat face	Narrower or edge face			
		Widths			
		≤ 30 mm	> 30 mm ≤ 50 mm	> 50 mm ≤ 80 mm	> 80 mm ≤ 105 mm
mm	mm	mm	mm	mm	mm
> 3 ≤ 10	0.2	0.40	0.65	0.80	1.00
> 10 ≤ 18	0.3				
> 18 ≤ 30	0.4				
> 30 ≤ 50	0.6				
> 50 ≤ 80	0.7				

NOTE The defect is to be measured perpendicular to the bar surface.

Table 11 — Flats equal to or less than 105 mm wide in hot and cold forging steels, and alloy steels: maximum permissible defect depths

Thickness	Maximum permissible defect depths				
	Wider or flat face	Narrower or edge face			
		Widths			
		≤ 30 mm	> 30 mm ≤ 50 mm	> 50 mm ≤ 80 mm	> 80 mm ≤ 105 mm
mm	mm	mm	mm	mm	mm
> 3 ≤ 10	0.15	0.20	0.30	0.50	0.70
> 10 ≤ 18	0.15				
> 18 ≤ 30	0.20				
> 30 ≤ 50	0.30				
> 50 ≤ 80	0.50				

NOTE The defect is to be measured perpendicular to the bar surface.

Table 12 — Chemical composition: free-cutting steels

Steel	C	Si	Mn	P	S
	%(m/m)	*%(m/m)*	*%(m/m)*	*%(m/m)*	*%(m/m)*
230M07	0.15 max.	0.05 max.	0.90 to 1.30	0.090 max.	0.25 to 0.35
216M36	0.32 to 0.40	0.25 max.	1.30 to 1.70	0.06 max.	0.12 to 0.20
212A42	0.40 to 0.45	0.25 max.	1.00 to 1.30	0.06 max.	0.12 to 0.20
226M44	0.40 to 0.48	0.25 max.	1.30 to 1.70	0.06 max.	0.22 to 0.30

Table 13 — Chemical composition: carbon and carbon manganese steels

Steel	C	Si	Mn	P	S
	%(m/m)	*%(m/m)*	*%(m/m)*	*%(m/m)*	*%(m/m)*
080A15	0.13 to 0.18	0.10 to 0.40	0.70 to 0.90	0.05 max.	0.05 max.
080M15	0.12 to 0.18	0.10 to 0.40	0.60 to 1.00	0.05 max.	0.05 max.
070M20	0.16 to 0.24	0.10 to 0.40	0.50 to 0.90	0.05 max.	0.05 max.
080A30	0.26 to 0.34	0.10 to 0.40	0.70 to 0.90	0.05 max.	0.05 max.
080M30	0.26 to 0.34	0.10 to 0.40	0.60 to 1.00	0.05 max.	0.05 max.
080M40	0.36 to 0.44	0.10 to 0.40	0.60 to 1.00	0.05 max.	0.05 max.
080A42	0.40 to 0.45	0.10 to 0.40	0.70 to 0.90	0.05 max.	0.05 max.
080A47	0.45 to 0.50	0.10 to 0.40	0.70 to 0.90	0.05 max.	0.05 max.
080M50	0.45 to 0.55	0.10 to 0.40	0.60 to 1.00	0.05 max.	0.05 max.
070M55	0.50 to 0.60	0.10 to 0.40	0.50 to 0.90	0.05 max.	0.05 max.
150M19	0.15 to 0.23	0.10 to 0.40	1.30 to 1.70	0.05 max.	0.05 max.
150M36	0.32 to 0.40	0.10 to 0.40	1.30 to 1.70	0.05 max.	0.05 max.

NOTE See also **3.3** g) and option **A.1**, **A.2** and **A.4**.

Table 14 — Chemical composition: case hardening steels (carbon and carbon manganese steels)

Steel	C	Si	Mn	P	S
	%(m/m)	*%(m/m)*	*%(m/m)*	*%(m/m)*	*%(m/m)*
045A10	0.08 to 0.13	0.10 to 0.40	0.30 to 0.60	0.05 max.	0.05 max.
045M10	0.07 to 0.13	0.10 to 0.40	0.30 to 0.60	0.05 max.	0.05 max.
080M15	0.12 to 0.18	0.10 to 0.40	0.60 to 1.00	0.05 max.	0.05 max.
210M15	0.12 to 0.18	0.10 to 0.40	0.90 to 1.30	0.05 max.	0.10 to 0.18

Table 15 — Chemical composition: alloy case hardening Steels[a]

Steel	C	Si	Mn	Cr	Mo	Ni
	%(m/m)	*%(m/m)*	*%(m/m)*	*%(m/m)*	*%(m/m)*	*%(m/m)*
635M15	0.12 to 0.18	0.10 to 0.40	0.60 to 0.90	0.4 to 0.80	—	0.70 to 1.10
637M17	0.14 to 0.20	0.10 to 0.40	0.60 to 0.90	0.60 to 1.00	—	0.85 to 1.25
655M13	0.10 to 0.16	0.10 to 0.40	0.35 to 0.60	0.70 to 1.00	—	3.00 to 3.75
665M17	0.14 to 0.20	0.10 to 0.40	0.35 to 0.75	—	0.20 to 0.30	1.50 to 2.00
805M17	0.14 to 0.20	0.10 to 0.40	0.60 to 0.95	0.35 to 0.65	0.15 to 0.25	0.35 to 0.75
805M20	0.17 to 0.23	0.10 to 0.40	0.60 to 0.95	0.35 to 0.65	0.15 to 0.25	0.35 to 0.75
815M17	0.14 to 0.20	0.10 to 0.40	0.60 to 0.90	0.80 to 1.20	0.10 to 0.20	1.20 to 1.70
820M17	0.14 to 0.20	0.10 to 0.40	0.60 to 0.90	0.80 to 1.20	0.10 to 0.20	1.50 to 2.00
822M17	0.14 to 0.20	0.10 to 0.40	0.40 to 0.70	1.30 to 1.70	0.15 to 0.25	1.75 to 2.25
835M15	0.12 to 0.18	0.10 to 0.40	0.25 to 0.50	1.00 to 1.40	0.15 to 0.30	3.90 to 4.30

NOTE See also **3.3** c), **3.3** i) and options **A.2** and **A.5**.

[a] Sulfur 0.05 % max., phosphorous 0.04 % max. for all qualities.

Table 16 — Chemical composition: alloy direct hardening steels

Steel	C	Si	Mn	P	S	Cr	Mo	Ni
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
530M40	0.36 to 0.44	0.10 to 0.40	0.60 to 0.90	0.035 max.	0.040 max.	0.90 to 1.20	—	—
605M36	0.32 to 0.40	0.10 to 0.40	1.30 to 1.70	0.035 max.	0.040 max.	—	0.22 to 0.32	—
606M36	0.32 to 0.40	0.10 to 0.40	1.30 to 1.70	0.035 max.	0.15 to 0.25	—	0.22 to 0.32	—
708M40	0.36 to 0.44	0.10 to 0.40	0.70 to 1.00	0.035 max.	0.040 max.	0.90 to 1.20	0.15 to 0.25	—
709M40	0.36 to 0.44	0.10 to 0.40	0.70 to 1.00	0.035 max.	0.040 max.	0.90 to 1.20	0.25 to 0.35	—
722M24	0.20 to 0.28	0.10 to 0.40	0.45 to 0.70	0.035 max.	0.040 max.	3.00 to 3.50	0.45 to 0.65	—
817M40	0.36 to 0.44	0.10 to 0.40	0.45 to 0.70	0.035 max.	0.040 max.	1.00 to 1.40	0.20 to 0.35	1.30 to 1.70
826M31	0.27 to 0.35	0.10 to 0.40	0.45 to 0.70	0.035 max.	0.040 max.	0.50 to 0.80	0.45 to 0.65	2.30 to 2.80
826M40	0.36 to 0.44	0.10 to 0.40	0.45 to 0.70	0.035 max.	0.040 max.	0.50 to 0.80	0.45 to 0.65	2.30 to 2.80
945M38	0.34 to 0.42	0.10 to 0.40	1.20 to 1.60	0.035 max.	0.040 max.	0.40 to 0.60	0.15 to 0.25	0.60 to 0.90

NOTE See also **3.3** c), **3.3** i) and options **A.2** and **A.5**.

Table 17 — Chemical composition: ferritic and martensitic stainless and heat resisting steels

Steel	Chemical composition (maximum unless range stated)								
	C	Si	Mn	P	S	Cr	Mo	Ni	Se
Ferritic steels									
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
403S17	0.08	1.0	1.0	0.040	0.030	12.0 to 14.0	—	0.50	—
430S17	0.08	1.0	1.0	0.040	0.030	16.0 to 18.0	—	0.50	—
Martensitic steels									
410S21	0.09 to 0.15	1.0	1.0	0.040	0.030	11.5 to 13.5	—	1.00	—
416S21	0.09 to 0.15	1.0	1.5	0.060	0.15 to 0.35	11.5 to 13.5	0.60	1.00	—
416S29	0.14 to 0.20	1.0	1.5	0.060	0.15 to 0.35	11.5 to 13.5	0.60	1.00	—
416S37	0.20 to 0.28	1.0	1.5	0.060	0.15 to 0.35	12.0 to 14.0	0.60	1.00	—
416S41	0.09 to 0.15	1.0	1.5	0.060	0.060	11.5 to 13.5	0.60	1.00	0.15 to 0.35
420S29	0.14 to 0.20	1.0	1.0	0.040	0.030	11.5 to 13.5	—	1.00	—
420S37	0.20 to 0.28	1.0	1.0	0.040	0.030	12.0 to 14.0	—	1.00	—
431S29	0.12 to 0.20	1.0	1.0	0.040	0.030	15.0 to 18.0	—	2.0 to 3.0	—

Table 18 — Chemical composition: austenitic stainless and heat resisting steels

Steel	Chemical composition (maximum unless range stated)							
	C	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**	**Others**
Austenitic steels									
	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)	%(*m*/*m*)
302S31	0.12	1.0	2.0	0.045	0.030	17.0 to 19.0	—	8.0 to 10.0	—
304S11	0.030	1.0	2.0	0.045	0.030	17.0 to 19.0	—	9.0 to 12.0	—
304S15	0.06	1.0	2.0	0.045	0.030	17.5 to 19.0	—	8.0 to 11.0	—
304S31	0.07	1.0	2.0	0.045	0.030	17.0 to 19.0	—	8.0 to 11.0	—
321S31	0.08	1.0	2.0	0.045	0.030	17.0 to 19.0	—	9.0 to 12.0	Ti 5C max. 0.80
347S31	0.08	1.0	2.0	0.045	0.030	17.0 to 19.0	—	9.0 to 12.0	Nb 10C max. 1.00
316S11	0.030	1.0	2.0	0.045	0.030	16.5 to 18.5	2.00 to 2.50	11.0 to 14.0	—
316S13	0.030	1.0	2.0	0.045	0.030	16.5 to 18.5	2.50 to 3.00	11.5 to 14.5	—
316S31	0.07	1.0	2.0	0.045	0.030	16.5 to 18.5	2.00 to 2.50	10.5 to 13.5	—
316S33	0.07	1.0	2.0	0.045	0.030	16.5 to 18.5	2.50 to 3.00	11.0 to 14.0	—
320S31	0.08	1.0	2.0	0.045	0.030	16.5 to 18.5	2.00 to 2.50	11.0 to 14.0	Ti 5C max. 0.80
310S31	0.15	1.5	2.0	0.045	0.030	24.0 to 26.0	—	19.0 to 22.0	—
303S31	0.12	1.0	2.0	0.060	0.15 to 0.35	17.0 to 19.0	1.00 (9)	8.0 to 10.0	—
303S42	0.12	1.0	2.0	0.060	0.060	17.0 to 19.0	1.00 (9)	8.0 to 10.0	Se 0.15 to 0.35
325S31	0.12	1.0	2.0	0.045	0.15 to 0.35	17.0 to 19.0	—	8.0 to 11.0	Ti 5C max. 0.90

Table 19 — Mechanical properties for free-cutting steels (18)

Steel	Condition (2)	Size (1) (diameter across flats or thickness)	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
230M07	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	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 to 700	340	20	34	28	310	152 to 207
		Q > 6 ≤ 63	625 to 775	400	18	34	28	370	179 to 229
		R > 6 ≤ 29	700 to 850	480	16	34	28	450	201 to 255
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P ≥ 29 < 100	550 to 700	380	15	34	—	340	152 to 207
		Q > 13 ≤ 63	625 to 775	440	13	34	—	400	179 to 229
		R > 6 ≤ 29	700 to 850	520	12	34	—	470	201 to 255
226M44	Hardened and tempered + turned or ground (1)	R ≥ 6 < 100	700 to 850	450	16	27	22	415	201 to 255
		S > 6 ≤ 29	775 to 925	525	14	20	16	495	223 to 277
		T > 6 ≤ 13	850 to 1 000	600	12	20	16	585	248 to 302
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground (4)	R ≥ 6 to < 100	700 to 850	525	12	27	—	435	201 to 255
		S > 6 to ≤ 29	775 to 925	575	10	20	—	520	223 to 277
		T > 6 to ≤ 13	850 to 1 000	630	9	20	—	600	248 to 302

[a] See also option **A.3**.

Table 20 — Mechanical properties for carbon and carbon manganese steels (18)

Steel	Condition (2)	Size (1) (diameter across flats or thickness)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
080M15	Normalized + turned or ground	≥ 6 ≤ 63	350 min.	175	22	—	—	—	109 to 163
		> 63 ≤ 150	330 min.	165	22	—	—	—	101 to 152
	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	Normalized + turned or ground	≥ 6 ≤ 150	430 min.	215	21	—	—	—	126 to 179
		> 150 ≤ 250	400 min.	200	21	—	—	—	116 to 170
	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	—
080M30	Normalized + turned or ground	≥ 6 ≤ 150	490 min.	245	20	—	—	—	143 to 192
		> 150 ≤ 250	460 min.	230	19	—	—	—	134 to 183
	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 to 700	340	18	34	28	310	152 to 207
		Q ≥ 6 ≤ 19	625 to 775	415	16	34	28	400	179 to 229
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P ≥ 6 ≤ 63	550 to 700	385	13	34	—	340	152 to 207
		Q ≥ 6 ≤ 19	625 to 775	460	12	34	—	430	179 to 229

[a] See also option **A.3**.

Table 20 — Mechanical properties for carbon and carbon manganese steels (18)

Steel	Condition (2)	Size (1) (diameter across flats or thickness)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
080M40	Normalized + turned or ground	≥ 6 ≤ 150	550 min.	280	16	20	16	—	152 to 207
		> 150 ≤ 250	510 min.	245	17	—	—	—	146 to 197
	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 to 775	385	16	34	28	355	179 to 229
		R ≥ 6 ≤ 19	700 to 850	465	16	34	28	450	201 to 255
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	Q ≥ 6 ≤ 63	625 to 775	435	12	34	—	380	179 to 229
		R ≥ 6 ≤ 19	700 to 850	490	12	34	—	460	201 to 255
080M50	Normalized + turned or ground	≥ 6 ≤ 150	620 min.	310	14	—	—	—	179 to 229
		> 150 ≤ 250	570 min.	295	14	—	—	—	163 to 217
	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 (4)	Q ≥ 6 ≤ 150	625 to 775	390	15	—	—	360	179 to 229
		R ≥ 6 ≤ 63	700 to 850	430	14	—	—	400	201 to 255
		S ≥ 6 ≤ 29	775 to 925	495	14	—	—	465	223 to 277
		T ≥ 6 ≤ 13	850 to 1 000	570	12	—	—	555	248 to 302
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground (4)	Q ≥ 13 ≤ 150	625 to 775	430	11	—	—	390	179 to 229
		R ≥ 6 ≤ 63	700 to 850	490	10	—	—	450	201 to 255
		S ≥ 6 ≤ 29	775 to 925	540	10	—	—	500	223 to 277
		T ≥ 6 ≤ 13	850 to 1 000	595	9	—	—	550	248 to 302
	Turned, ground or cold drawn and finally softened	—	—	—	—	—	—	—	187 max.

[a] See also option **A.3**.

Table 20 — Mechanical properties for carbon and carbon manganese steels (18)

Steel	Condition (2)	Size (1) (diameter across flats or thickness)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
070M55	Normalized + turned or ground	≥ 6 ≤ 63	700 min.	355	12	—	—	—	201 to 255
		> 63 ≤ 250	600 min.	310	13		—	—	170 to 223
	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 (4)	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 (4)	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
	Turned, ground or cold drawn and finally softened	—	—	—	—	—	—	—	201 max.
150M19	Normalized + turned or ground	≥ 6 ≤ 150	550 min.	325	18	40	35	—	152 to 207
		> 150 ≤ 250	510 min.	295	17	—	—	—	146 to 197
	Hardened and tempered + turned or ground	P > 13 ≤ 150	550 to 700	340	18	54	50	325	152 to 207
		Q ≥ 6 ≤ 63	625 to 775	430	16	54	50	415	179 to 229
		R ≥ 6 ≤ 29	700 to 850	510	16	40	35	495	201 to 255
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	P > 19 ≤ 150	550 to 700	360	13	54	—	345	152 to 207
		Q ≥ 6 ≤ 63	625 to 775	450	12	54	—	435	179 to 229
		R ≥ 6 ≤ 29	700 to 850	520	12	40	—	510	201 to 255
150M36	Normalized + turned or ground	≥ 6 ≤ 150	620 min.	385	14	—	—	—	179 to 229
		> 150 ≤ 250	600 min.	355	15	—	—	—	170 to 223
	Hardened and tempered + turned or ground (4)	Q > 19 ≤ 150	625 to 775	400	18	47	42	370	179 to 229
		R > 13 ≤ 63	700 to 850	480	16	41	35	450	201 to 255
		S ≥ 6 ≤ 29	775 to 925	555	14	41	35	525	223 to 277
		T ≥ 6 ≤ 13	850 to 1 000	635	12	34	28	620	248 to 302
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground (4)	Q > 19 ≤ 150	625 to 775	440	13	47	—	400	179 to 229
		R > 13 ≤ 63	700 to 850	520	12	41	—	480	201 to 255
		S ≥ 6 ≤ 29	775 to 925	580	10	41	—	540	223 to 277
		T ≥ 6 ≤ 13	850 to 1 000	665	9	34	—	635	248 to 302

[a] See also option **A.3**.

Table 21 — Mechanical properties for alloy steels (18)

Steel	Condition (2)	Size (1) (diameter across flats, or thickness)	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
530M40	Hardened and tempered + turned or ground	R > 63 ≤ 100	700 to 850	525	17	54	50	510	201 to 255
		S ≥ 6 ≤ 63	775 to 925	585	15	54	50	570	223 to 277
		T ≥ 6 ≤ 29	850 to 1 000	680	13	54	50	665	248 to 302
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 63 ≤ 100	700 to 850	540	12	54	—	525	201 to 255
		S > 13 ≤ 63	775 to 925	600	11	54	—	585	223 to 277
		T ≥ 6 ≤ 29	850 to 1 000	700	9	54	—	680	248 to 302
	Turned, ground or cold drawn and finally softened								229 max.
605M36	Hardened and tempered + turned or ground	R >150 ≤ 250	700 to 850	495	15	34	28	480	201 to 255
		R > 29 ≤ 150	700 to 850	525	17	54	50	510	201 to 255
		S > 13 ≤ 100	775 to 925	585	15	54	50	570	223 to 277
		T ≥ 6 ≤ 63	850 to 1 000	680	13	54	50	665	248 to 302
		U ≥ 6 ≤ 29	925 to 1 075	755	12	47	42	740	269 to 331
		V ≥ 6 ≤ 19	1 000 to 1 150	850	12	47	42	835	293 to 352
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 29 ≤ 150	700 to 850	540	12	54	—	525	201 to 255
		S > 13 ≤ 100	775 to 925	600	11	54	—	585	223 to 277
		T ≥ 6 ≤ 63	850 to 1 000	700	9	54	—	680	248 to 302
		U ≥ 6 ≤ 29	925 to 1 075	770	9	47	—	755	269 to 331
		V ≥ 6 ≤ 19	1 000 to 1 150	865	9	47	—	850	293 to 352
	Turned, ground or cold drawn and finally softened								241 max.
606M36	Hardened and tempered + turned or ground	R > 13 ≤ 100	700 to 850	525	15	54	50	510	201 to 255
		S ≥ 6 ≤ 63	775 to 925	585	13	47	42	570	223 to 277
		T ≥ 6 ≤ 29	850 to 1 000	680	11	40	35	665	248 to 302
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 29 ≤ 100	700 to 850	540	11	47	—	525	201 to 255
		S ≥ 6 ≤ 63	775 to 925	600	10	47	—	585	223 to 277
		T ≥ 6 ≤ 29	850 to 1 000	700	8	40	—	680	248 to 302
	Turned, ground or cold drawn and finally softened								229 max.

[a] See also option **A.3**.

Table 21 — Mechanical properties for alloy steels (18)

Steel	Condition (2)	Size (1) (diameter across flats, or thickness)	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a] Izod min.	Impact[a] KCV min.	$R_{p0.2}$ (3) min.	HB (13)
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
708M40	Hardened and tempered + turned or ground	$R > 150 \leq 250$	700 to 850	495	15	34	28	480	201 to 255
		$R > 63 \leq 150$	700 to 850	525	17	54	50	510	201 to 255
		$S > 29 \leq 100$	775 to 925	585	15	54	50	570	223 to 277
		$T \geq 6 \leq 63$	850 to 1 000	680	13	54	50	665	248 to 302
		$U \geq 6 \leq 29$	925 to 1 075	755	12	47	42	740	269 to 331
		$V \geq 6 \leq 19$	1 000 to 1 150	850	12	47	42	835	293 to 352
	(4)(6)	$W \geq 6 \leq 13$	1 075 to 1 225	940	12	40	35	925	311 to 375
	Hardened and tempered + cold drawn or hardened + tempered + cold drawn + ground	$R > 63 \leq 150$	700 to 850	540	12	54	—	525	201 to 255
		$S > 29 \leq 100$	775 to 925	600	11	54	—	585	223 to 277
		$T \geq 6 \leq 63$	850 to 1 000	700	9	54	—	680	248 to 302
		$U \geq 6 \leq 29$	925 to 1 075	770	9	47	—	755	269 to 331
		$V \geq 6 \leq 19$	1 000 to 1 150	865	9	47	—	850	293 to 352
	(4)(6)	$W \geq 6 \leq 13$	1 075 to 1 225	955	8	40		940	311 to 375
	Turned, ground or cold drawn and finally softened								248 max.
709M40	Hardened and tempered + turned or ground	$R > 100 \leq 250$	700 to 850	495	15	34	28	480	201 to 255
		$S > 150 \leq 250$	775 to 925	555	13	27	22	540	223 to 277
		$S > 63 \leq 150$	775 to 925	585	15	54	50	570	223 to 277
		$T > 29 \leq 100$	850 to 1 000	680	13	54	50	665	248 to 302
		$U > 13 \leq 63$	925 to 1 075	755	12	47	42	740	269 to 331
	(4)(6)	$V \geq 6 \leq 29$	1 000 to 1 150	850	12	47	42	835	293 to 352
	(6)	$W \geq 6 \leq 19$	1 075 to 1 225	940	12	40	35	925	311 to 375
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	$R > 100 \leq 150$	700 to 850	540	11	54	—	510	201 to 255
		$S > 63 \leq 150$	775 to 925	600	11	54	—	585	223 to 277
		$T > 29 \leq 100$	850 to 1 000	700	9	54	—	680	248 to 302
		$U > 13 \leq 63$	925 to 1 075	770	9	47	—	755	269 to 331
	(4)(6)	$V \geq 6 \leq 29$	1 000 to 1 150	865	9	47	—	850	293 to 352
		$W \geq 6 \leq 19$	1 075 to 1 225	955	8	40	—	940	311 to 375
	Turned, ground or cold drawn and finally softened								255 max.

[a] See also option **A.3**.

Table 21 — Mechanical properties for alloy steels (18)

Steel	Condition (2)	Size (1) (diameter across flats, or thickness)	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
722M24	Hardened and tempered + turned or ground	$T > 150 \leq 250$	850 to 1 000	650	13	40	35	635	248 to 302
		$T \geq 6 \leq 150$	850 to 1 000	680	13	54	50	665	248 to 302
		$U \geq 6 \leq 150$	925 to 1 075	755	12	47	42	740	269 to 331
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	$T \geq 6 \leq 150$	850 to 1 000	700	9	54	—	680	248 to 302
		$U \geq 6 \leq 150$	925 to 1 075	770	9	47	—	755	269 to 331
	Turned, ground or cold drawn and finally softened								269 max.
817M40	Hardened and tempered + turned or ground	$T > 150 \leq 250$	850 to 1 000	650	13	40	35	635	248 to 302
		$T > 63 \leq 150$	850 to 1 000	680	13	54	50	665	248 to 302
		$U > 29 \leq 100$	925 to 1 075	755	12	47	42	740	269 to 331
		$V > 13 \leq 63$	1 000 to 1 150	850	12	47	42	835	293 to 352
	(6)	$W \geq 6 \leq 29$	1 075 to 1 225	940	11	40	35	925	311 to 375
	(1)(6)	$X \geq 6 \leq 29$	1 150 to 1 300	1 020	10	34	28	1 005	341 to 401
	(1)(6)	$Z \geq 6 \leq 29$	1 550 min.	1 235	5	10	9	1 125	444 min.
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	$T > 63 \leq 150$	850 to 1 000	700	9	54	—	680	248 to 302
		$U > 29 \leq 100$	925 to 1 075	770	9	47	—	755	269 to 331
		$V > 13 \leq 63$	1 000 to 1 150	865	9	47	—	850	293 to 352
	(4)(6)(7)	$W \geq 6 \leq 29$	1 075 to 1 225	955	8	40	—	940	311 to 375
	(4)(6)(7)	$X \geq 6 \leq 29$	1 150 to 1 300	1 035	7	34	—	1 020	341 to 401
	(4)(6)(7)	$Z \geq 6 \leq 29$	1 550 min.	1 250	3	11	—	1 235	444 min.
	Turned, ground or cold drawn and finally softened								277 max.

[a] See also option **A.3**.

Table 21 — Mechanical properties for alloy steels (18)

Steel	Condition (2)	Size (1) (diameter across flats, or thickness)	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a] Izod min.	Impact[a] KCV min.	$R_{p0.2}$ (3) min.	HB (13)
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
826M31	Hardened and tempered and turned or ground	$T > 150 \leq 250$	850 to 1 000	650	13	40	35	635	248 to 302
		$T > 100 \leq 150$	850 to 1 000	680	13	54	50	665	248 to 302
		$U > 150 \leq 250$	925 to 1 075	740	12	34	28	725	269 to 331
		$U > 100 \leq 150$	925 to 1 075	755	12	47	42	740	269 to 331
		$V > 63 \leq 150$	1 000 to 1 150	850	12	47	42	835	293 to 352
	(6)	$W > 29 \leq 100$	1 075 to 1 225	940	11	40	35	925	311 to 375
	(6)	$X > 13 \leq 63$	1 150 to 1 300	1 020	10	34	28	1 005	341 to 401
	(6)	$Z > 13 \leq 63$	1 550 min.	1 235	5	10	9	1 125	444 min.
	Hardened and tempered and cold drawn or hardened and tempered and cold drawn and ground	$T > 63 \leq 150$	850 to 1 000	700	9	54	—	680	248 to 302
		$U > 29 \leq 100$	925 to 1 075	770	9	47	—	755	269 to 331
		$V > 29 \leq 100$	1 000 to 1 150	885	9	47	—	850	293 to 362
	(4)(6)(7)	$W > 29 \leq 100$	1 075 to 1 225	955	8	40	—	940	311 to 375
	(4)(6)(7)	$X > 6 \leq 63$	1 150 to 1 300	1 035	7	34	—	1 020	341 to 401
	(4)(6)(7)	$Z > 6 \leq 63$	1 550 min.	1 250	3	10	—	1 235	444 min.
	Turned, ground or cold drawn and finally softened	—	—	—	—	—	—	—	277 max.
826M40	Hardened and tempered + turned or ground	$U > 150 \leq 250$	925 to 1 075	740	12	34	28	725	269 to 331
		$U > 100 \leq 150$	925 to 1 075	755	12	47	42	740	269 to 331
		$V > 63 \leq 250$	1 000 to 1 150	835	12	34	28	820	293 to 352
	(6)	$V > 63 \leq 150$	1 000 to 1 150	850	12	47	42	835	293 to 352
	(6)	$W > 29 \leq 250$	1 075 to 1 225	925	11	27	22	910	311 to 375
	(6)	$W > 29 \leq 150$	1 075 to 1 225	940	11	40	35	925	311 to 375
	(6)	$X > 29 \leq 150$	1 150 to 1 300	1 020	10	34	28	1 005	341 to 401
	(6)	$Y > 29 \leq 150$	1 225 to 1 375	1 095	10	34	28	1 080	363 to 429
		$Z > 29 \leq 100$	1 550 min.	1 235	7	13	11	1 125	444 min. (4)
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	$U > 100 \leq 150$	925 to 1 075	770	9	47	—	755	269 to 331
		$V > 63 \leq 150$	1 000 to 1 150	865	9	47	—	850	293 to 352
		$W > 29 \leq 150$	1 075 to 1 225	955	8	40	—	940	311 to 375
	(1)(4)(6)(7)	$X > 29 \leq 150$	1 150 to 1 300	1 035	7	34	—	1 020	341 to 401
	(1)(4)(6)(7)	$Y > 29 \leq 150$	1 225 to 1 375	1 110	7	34	—	1 095	363 to 429
	(1)(4)(6)(7)	$Z > 29 \leq 100$	1 550 min. (12)	1 250	5	13	—	1 235	444 min.
	Turned, ground or cold drawn and finally softened								277 max.

[a] See also option **A.3**.

Table 21 — Mechanical properties for alloy steels (18)

Steel	Condition (2)	Size (1) (diameter across flats, or thickness)	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB (13)
						Izod min.	KCV min.		
		mm	N/mm^2	N/mm^2	%	J	J	N/mm^2	
945M38	Hardened and tempered + turned or ground	R > 150 ≤ 250	700 to 850	495	15	34	28	480	201 to 255
		R>100 ≤ 150	700 to 850	525	17	54	50	510	201 to 255
		S > 63 ≤ 100	775 to 925	585	15	54	50	570	223 to 277
		T > 29 ≤ 63	850 to 1 000	680	13	54	50	665	248 to 302
		U ≥ 6 ≤ 29	925 to 1 075	755	12	47	42	740	269 to 331
		V ≥ 6 ≤ 29	1 000 to 1 150	850	12	47	42	835	293 to 352
	Hardened and tempered + cold drawn or hardened and tempered + cold drawn + ground	R > 100 ≤ 150	700 to 850	540	13	54	50	525	201 to 255
		S > 63 ≤ 100	775 to 925	600	11	54	50	585	223 to 277
		T > 29 ≤ 63	850 to 1 000	700	10	54	50	680	248 to 302
		U ≥ 6 ≤ 29	925 to 1 075	770	9	47	42	755	269 to 331
		V ≥ 6 ≤ 29	1 000 to 1 150	865	9	47	42	850	293 to 352
	Turned, ground or cold drawn and finally softened								277 max.

[a] See also option **A.3**.

Table 22 — Mechanical properties for case hardening steels

Steel	Test bar diameter	R_m min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a]		HB (max.) (14) normalized	HB max. (14)		Hardening Temperature
				Izod min.	KCV min.		Subcritically annealed	Normalized and tempered	
	mm	N/mm^2	%	J	J				°C
Carbon steels									
045M10	13	430	18	47	42	—	—	—	—
045A10	19 (5)	430	18	47	42	—	—	—	—
080M15	13	490	16	40	35	—	—	—	—
	19 (5)	460	16	40	35	—	—	—	—
	29	430	18	40	35	—	—	—	—
Carbon manganese steels									
210M15	13	490	16	40	35	—	—	—	—
	19 (5)	460	16	40	35	—	—	—	—
	29	430	18	40	35	—	—	—	—
Alloy steel									
635M15	19	770	12	27	22	207	—	—	820 to 840
637M17	19	930	10	20	16	217	—	—	820 to 840
655M13	19	1 000	9	40	35	—	255	223	800 to 820
655M17	19	770	12	40	35	207	—	—	820 to 840
805M17	19	770	12	27	22	207	—	—	820 to 840
805M20	19	850	11	20	16	207	—	—	820 to 840
815M17	19	1 080	8	27	22	—	255	241	820 to 840
820M17	19	1 160	8	27	22	—	269	248	820 to 840
822M17	19	1 310	8	27	22	—	269	255	820 to 840
835M15	19	1 310	8	34	28	—	277	269	800 to 820[b]

[a] See also option **A.3**.

[b] Also to be stress relieved at not greater than 200 °C.

NOTE Mechanical tests are in the blank carburized condition. Hardness figures are in the condition stated.

Table 23 — Heat treatment and mechanical properties for ferritic and martensitic stainless and heat resisting steels (18)

Steel	Softened condition HB max.	Heat treatment condition	LRS	Heat treatment	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB
								Izod min.	KCV min.		
			mm	°C	N/mm^2	N/mm^2	%	J	J	N/mm^2	
Ferritic steels											
403S17	170	—	150	700 to 780 (16)	420 min.	280	20	—	—	245	170 max.
430S17	170	—	63	750 to 820 (17)	430 min.	280	20	—	—	245	170 max.
Martensitic steels											
410S21	207			950 to 1 020 (10)							
		P	150	650 to 750 (11)	550 to 700	370	20	< 63 mm: 54 ≥ 63 mm: 34	—	340	152 to 207
		R	63	600 to 700 (11)	700 to 850	525	15		—	495	201 to 255
416S21	207			950 to 1 020							
		P	150	650 to 750	550 to 700	370	15	34	—	340	152 to 207
		R	63	600 to 700 (11)	700 to 850	525	11	27	—	495	201 to 255
416S29	217			950 to 1 020 (10)							
		R	150	650 to 750 (11)	700 to 850	525	11	27	—	495	201 to 255
		S	29	600 to 700 (11)	775 to 925	585	10	13	—	555	223 to 277
416S37	229			950 to 1 020 (10)							
		R	150	650 to 750 (11)	700 to 850	525	11	27	—	495	201 to 255
		S	150	600 to 700 (11)	775 to 925	585	10	13	—	555	223 to 277
416S41	179			950 to 1 020 (10)							
		P	150	650 to 750 (10)	550 to 700	370	15	34	—	340	152 to 207
		R	63	600 to 700 (11)	700 to 850	525	11	27	—	495	201 to 255
420S29	217			950 to 1 020 (10)							
		R	150	650 to 750 (11)	700 to 850	525	15	< 63 mm: 34 ≥ 63 mm: 27	—	495	201 to 255
		S	29	600 to 700 (11)	775 to 925	585	13		—	555	223 to 277

Table 23 — Heat treatment and mechanical properties for ferritic and martensitic stainless and heat resisting steels (18)

Steel	Softened condition HB max.	Heat treatment condition	LRS	Heat treatment	R_m	R_e min.	A min. on 5.65 $\sqrt{S_o}$	Impact[a]		$R_{p0.2}$ (3) min.	HB
								Izod min.	KCV min.		
			mm	°C	N/mm^2	N/mm^2	%	J	J	N/mm^2	
420S37	229			950 to 1 020 (10)							
		R	150	650 to 750 (11)	700 to 850	525	15	< 63 mm: 34 ≥ 63 mm: 27	—	495	210 to 255
		S	150	600 to 700 (11)	775 to 925	585	13	< 63 mm: 27 ≥ 63 mm: 14	—	555	223 to 277
431S29	277			950 to 1 020							
		T	150	550 to 650	850 to 1 000	680	11	< 63 mm: 34 ≥ 63 mm: 20	—	635	248 to 302

[a] See also option **A.3**.

Table 24 — Softening treatment and mechanical properties for austenitic stainless and heat resisting steels in the finally softened condition[a] (15)

Steel	R_m min.	A min. on 5.65 $\sqrt{S_o}$	$R_{p0.2}$ (3)	$R_{p1.0}$ min.	Sensitization period (see 8.6)
	N/mm^2	%	N/mm^2	N/mm^2	min
302S31	510	40	190	225	—
304S11	480	40	180	215	30
304S15	480	40	195	230	15
304S31	490	40	195	230	15
321S31	510	35	200	235	30
347S31	510	30	205	240	30
316S11	490	40	190	225	30
316S13	490	40	190	225	30
316S31	510	40	205	240	15
316S33	510	40	205	240	15
320S31	510	35	210	245	30
310S31	510	40	205	240	—
303S31	510	40	190	225	—
303S42	510	40	190	225	—
325S31	510	35	200	235	30

[a] These figures are applicable to sections up to 160 mm softened at 1 000 °C to 1 100 °C.

Table 25 — Mechanical properties for austenitic stainless steels in the cold drawn condition (15)

Section	R_m min.	A min. on 5.65 $\sqrt{S_o}$	$R_{p0.2}$ min.	$R_{p1.0}$ min.
mm	N/mm^2	%	N/mm^2	N/mm^2
≤ 19	865	12	695	725
> 19 ≤ 25	790	15	555	585
> 25 ≤ 32	725	20	450	480
> 32 ≤ 38	695	28	340	370
> 38 ≤ 45	650	28	310	340

Table 26 — Mechanical properties for austenitic stainless steels in the softened and finally cold drawn condition (15)

Section	R_m min.	A min. on 5.65 $\sqrt{S_o}$	$R_{p0.2}$ min.	$R_{p1.0}$ min.
mm	N/mm^2	%	N/mm^2	N/mm^2
≤ 19	600	15	375	425
> 19	550	20	325	375

Table 27 — Normalizing for carbon and carbon manganese steels

Steel	Normalizing temperature
	°C
080M15	890 to 920
070M20	880 to 910
080M30	860 to 890
080M40	830 to 860
080M50	810 to 840
070M55	810 to 840
150M19	860 to 900
150M36	840 to 870

Table 28 — Hardening and tempering parameters for free-cutting, carbon and carbon manganese, and alloy steels

Steel	Hardening treatment		Tempering temperature
	Temperature	Quench medium	
	°C		°C
080M30	860 to 890	Oil or water	550 to 660
080M40	830 to 860	Oil	550 to 660
080M50	810 to 840	Oil	550 to 660
070M5	810 to 840	Oil	550 to 660
150M19	860 to 900	Oil or water	550 to 660
150M36	840 to 870	Oil	550 to 660
212M36	840 to 870	Oil	550 to 660
226M44	830 to 860	Oil	550 to 660
530M40	850 to 880	Oil	550 to 700
605M36	840 to 870	Oil	550 to 680
606M36	840 to 870	Oil	550 to 680
709M40	860 to 890	Oil	550 to 700
722M24	880 to 910	Oil	550 to 700
817M40	820 to 850	Oil	660 max.[a]
826M40	820 to 850	Oil	660 max.[a]
945M38	840 to 870	Oil	550 to 680

[a] For these steels the temperature range 280 °C to 500 °C has to be avoided.

Notes to Table 12 to Table 28

1) For cold drawn bar of a diameter or across flat section of less than 6 mm all mechanical properties should be agreed at the time of enquiry and/or order.
2) Normalizing temperatures and hardening and tempering temperatures are given in Table 27 and Table 28.
3) When specifically ordered.
4) Properties cannot always be obtainable by bulk heat treatment of bar but these properties can be achieved by the appropriate heat treatment of components by the purchaser.
5) Preferred size.
6) Often ordered in the softened condition for machining and subsequent heat treatment to achieve these specified mechanical properties.
7) Cold drawn bars are not normally available in this tensile strength range.
8) A maximum silicon content can be agreed between the purchaser and the supplier.
9) Optional addition.
10) Oil or air hardened.
11) Tempered.
12) When 0.2 % proof stress is specified it is recommended that a double tempering treatment be used:
    a) 640 °C to 680 °C followed by
    b) 590 °C to 610 °C
13) Brinell hardness for guidance only except where material is supplied in the softened condition.
14) Maximum hardness HB (when specified on the order) in the condition of delivery.
15) For magnetic properties see also option **A.2**.
16) Air cooled or furnace cooled.
17) Cooled freely in air.
18) The various tensile strength ranges for the different specifications have been designated with the reference symbol *P* to *Z*, as given in Table 29.

Table 29 — Reference symbols for tensile strength ranges of hardened and tempered material

Reference symbol	Tensile strength[a]
	N/mm^2
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 min.

[a] 1 N/mm^2 = 1 MPa
NOTE Other mechanical properties associated with these ranges are as indicated in the relevant tables.

Appendix A Options

NOTE These options may be agreed at the time of enquiry and/or order.

A.1 Hardness tests shall be required for bars supplied in the non-heat treated condition (see **4.2**).

A.2 Certification giving chemical analysis and/or mechanical properties and/or hardenability values shall be supplied (see **4.5**).

A.3 If the standard impact test specified in BS 131-1 is not required KCV values shall be specified (see **8.2**).

A.4 An intercrystalline corrosion test for stainless steels shall be carried out for each cast of steel supplied. If specified a bend test sample 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, followed by cooling in still air. The other provisions of BS 5903 shall apply (see **8.6**).

A.5 Where steels containing lead are required, the lead range shall be stated in the order. If not specifically stated the lead content shall be not less than 0.15 % and not greater than 0.35 % on cast analysis (see **9.1** and **9.3**).

Publication(s) referred to:

BS 131, *Notched bar tests.*

BS 131-1, *The Izod impact test on metals.*

BS 240, *Method for Brinell hardness test and for verification of Brinell hardness testing machines.*

BS 970, *Specification for wrought steels for mechanical and allied engineering purposes.*

BS 970-1, *General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels.*

BS 1134, *Assessment of surface texture.*

BS 1134-1, *Methods and instrumentation.*

BS 4437, *Method for determining hardenability of steel by end quenching (Jominy test).*

BS 4490, *Methods for micrographic determination of the grain size of steel.*

BS 5903, *Method for determination of resistance to intergranular corrosion of austenitic stainless steels: copper sulphate-sulphuric acid method (Moneypenny Strauss test).*

BS 6200, *Sampling and analysis of iron, steel and other ferrous metals.*

BS 6200-3, *Methods of analysis.*

BS 6617, *Determination of decarburization in steel.*

BS 6617-1, *Methods for determining decarburization by microscopic and micro-hardness techniques.*

BS 6617-2, *Methods for determining decarburization by chemical and spectrographic analysis techniques.*

BS Handbook 19, *Methods for the sampling and analysis of iron, steel and other ferrous metals.*

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

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