

BRITISH STANDARD 970 : 1955

WROUGHT STEELS

IN THE FORM OF BARS, BILLETS AND FORGINGS

UP TO 6 IN. RULING SECTION

FOR AUTOMOBILE

AND GENERAL ENGINEERING

PURPOSES

(En SERIES)

Incorporating amendments issued Feb., 1955 (PD 2127),
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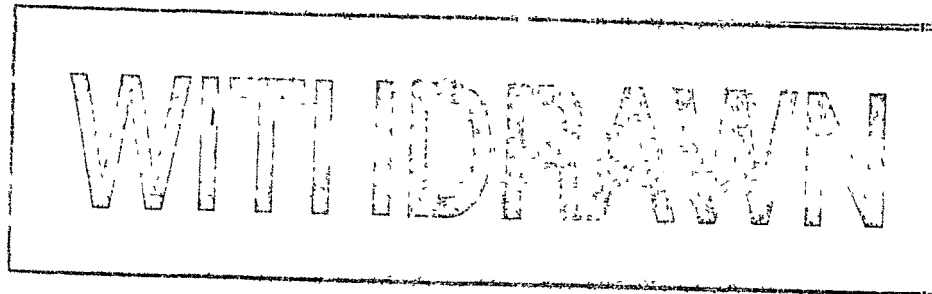
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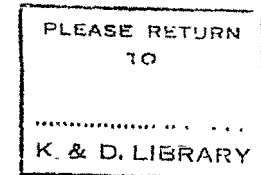
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26 MAR 1965



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First revision, October, 1942
Second revision, March, 1947
Third revision, January, 1955

The Institution desires to call attention to the fact that this schedule does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 4,000 indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook.

This schedule makes reference to the following British Standards:—

- B.S. 18 Tensile testing of metals.
B.S. 131. Forms of notched bar impact test pieces.
B.S. 240 Part 1. Methods and tables for Brinell hardness testing.
Part 2. Steel balls for Brinell hardness testing
B.S. 427 Tables of diamond pyramid hardness numbers.
B.S. 860. Table of approximate comparison of hardness scales.
B.S. 1408. Hard drawn steel wire for springs.
B.S. 1429. Annealed steel wire for oil-hardened and tempered springs.
B.S. 1449. Steel plate, sheet and strip.
B.S. 1554. Rust, acid and heat-resisting steel wire.
B.S. 1639. Notes on simple bend test.
B.S. 2056. Rust, acid and heat-resisting steel wire for springs.
B.S. 2094. Glossary of terms relating to iron and steel; Part 1.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following B.S.I. references relate to the work on this standard —
Committee reference ISE/31 Draft for comment CO(ISE)4583

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CO-OPERATING ORGANIZATIONS

The Iron and Steel Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations :—

- *Admiralty
- *Alloy Steels Association
- British Cast Iron Research Association
- British Constructional Steelwork Association
- *British Electrical and Allied Manufacturers' Association
- British Engineers' Association
- *British Iron and Steel Federation
- British Ironfounders' Association
- *British Railways, British Transport Commission
- British Steel Castings Research Association
- British Steel Founders' Association
- British Steel Wire Industries Association
- Council of Iron Producers
- Council of Ironfoundry Associations
- Crown Agents for Oversea Governments and Administrations
- Federation of Civil Engineering Contractors
- Institute of British Foundrymen
- *Institute of Marine Engineers
- Institution of Civil Engineers
- Institution of Mechanical Engineers (Automobile Division)
- Institution of Structural Engineers
- Iron and Steel Institute
- Joint Iron Council
- Lloyds Register of Shipping
- Ministry of Housing and Local Government
- Ministry of Labour and National Service (Factory Department)
- *Ministry of Supply
- *National Association of Drop-Forgers and Stampers
- National Ironfounding Employers' Federation
- National Physical Laboratory
- Royal Institute of British Architects
- Shipbuilding Employers' Federation
- Society of British Aircraft Constructors

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard :—

- British Bolt, Nut, Screw and Rivet Conference
- Coil Spring Federation Research Organization
- Institution of Engineering Inspection
- Ministry of Transport and Civil Aviation
- National Coal Board
- Railway Carriage and Wagon Building Association
- Society of Motor Manufacturers and Traders Ltd.
- Stainless Steel Fabricators Association of Great Britain

BRITISH STANDARD SCHEDULE OF
STEELS FOR AUTOMOBILE AND GENERAL
ENGINEERING PURPOSES

FOREWORD

The first edition of this specification was issued in 1941 not only to replace B.S. 5005 : 1924, which, until then, was the only specification for wrought steel for automobiles, but also to provide a comprehensive schedule of steels for general use in the engineering industries.

In accordance with the policy of the British Standards Institution, revisions were subsequently issued in 1942 and 1947 to bring the schedule into line with current practice. This particularly affected the 1947 issue, which, as a result of discussion with the Society of Motor Manufacturers and Traders, included the post-war requirements of the motor industry.

The present revision brings the specifications up to date and at the same time has been designed to cover the requirements of the Services as far as they are compatible with those of industry in general.

The particular requirements of the motor industry meant that, since 1947, sub-divisions have been introduced into certain specifications to meet the needs of some users whose heat treatment facilities require material of closely controlled chemical composition. In these specifications the parent specification details limits of composition generally acceptable as suitable for the particular class of steel as well as the mechanical properties obtainable within the ruling sections stated for the material within these composition limits. The sub-divisions of the specification require some closely controlled limits of composition, but in such cases specified mechanical properties are not a contractual obligation and the material is supplied only to the limits of the composition specified.

It has been found possible to meet most of the requirements of the Services without conflicting with the requirements of the automobile and general engineering industries except for the special case of proof stresses for certain steels. Proof tests are included in appropriate cases for use where specifically requested in the enquiry and order, and in the absence of such a specific request the material supply will not be so tested.

The case hardening steels of the En 350 and En 360 series, introduced as Addendum No. 1 in 1951 at the instigation of the Steel (Re-armament) Panel, Ministry of Supply, have been incorporated in this revision.

In this issue, as in previous issues, an important feature is the attention paid to the effect of the ruling section of the material at the time of heat treatment upon the mechanical properties obtained.

As a complementary document to the various issues of B.S. 970, there has been published B.S. 971 'Commentary on B.S. wrought steels (En

series)'. This contains a large amount of valuable and informative data to facilitate the task of designers in selecting the most suitable and at the same time the most economical steel, with particular reference to the effect of mass upon the properties obtained. The last edition was issued in 1950 and a new edition will be published on the basis of this edition of B.S. 970.

PART 1. GENERAL CLAUSES

Ruling section. In the selection of a steel one of the most important considerations is whether the mechanical properties required can be obtained from the steel in the size and shape at the time of heat treatment. That portion which is most important from the point of view of the mechanical properties obtained by heat treatment is referred to as the ruling section and the ruling section should always be expressed in terms of the diameter of an equivalent round bar (see Appendix E).

Some of the specifications in Part 2 state the maximum diameter of round bar, i.e. the limiting ruling section, in which certain mechanical properties can be obtained. The designer should select steel which will give the desired properties in the actual ruling section at the time of heat treatment. When ordering steel not supplied in the finally heat treated condition the ruling section of the part at the time of heat treatment should be stated.

It is emphasized that the limiting ruling sections stated in the specifications in Part 2 are the maximum sizes in which the specified properties can be guaranteed.

GENERAL REQUIREMENTS

1. The steel shall comply with the requirements specified in this part and with the appropriate requirements specified in Part 2. The steel shall be supplied to both the chemical analysis and the mechanical tests unless the order states otherwise, but where mechanical tests are not a contractual obligation of the specification the material shall be supplied to chemical composition only.

In order to assist the supplier, the purchaser is recommended to indicate in the enquiry and order the purpose for which the material is to be used. A drawing of the part in question is useful.

*As added
Feb 1963*

STEELMAKING PROCESS

2. The steelmaking process shall be at the option of the manufacturer unless otherwise specified in the order.

FREEDOM FROM DEFECTS

3. The steel shall be free from piping, harmful segregation and other defects and in addition:

*As altered
Feb 1961*

a Billets and bars for forgings shall be rough machined, chipped, ground or otherwise prepared to remove surface defects which might produce defects in the bars, forgings or drop forgings made therefrom;

b Billets for re-rolling and bars for other than forging purposes shall be free from harmful surface defects;

- c. Bars for machining shall be commercially straight;
 d. Forgings and drop forgings shall be finished in a workmanlike manner and shall be free from flaws and surface defects;
 e. Case hardening steels shall be capable of being carburised and heat-treated to give a satisfactory uniform surface hardness.

CHEMICAL ANALYSIS

4. a. *Specified analysis* The specified ranges of chemical composition are based on cast analyses and on request the manufacturer shall supply a certificate of analysis of the steel for the specified elements. Any subsequent analytical checks shall take into consideration the heterogeneity of the steel.

b. *Residual elements.* For carbon steels elements not quoted in the relevant specification shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition of such elements from scrap or other materials used in manufacture.

For alloy steels percentages of elements up to the following amounts shall be considered as incidental —

Nickel	0.40 per cent
Chromium	0.30 per cent
Molybdenum	0.15 per cent
Vanadium	0.05 per cent

For special applications the purchaser, by agreement with the supplier, may set a limit to the amount of one or more residual elements and/or may require the amount of such elements to be stated in the certificate of analysis.

c. *Optional elements.* In certain specifications optional elements are included for use at the discretion of the steelmaker in order to obtain the desired properties.

d. *Lead bearing steels.* Lead bearing steels may be supplied only by agreement between purchaser and supplier. The lead content shall be 0.15/0.35 per cent, and the steel shall be identifiable by a distinguishing mark agreed between the purchaser and the supplier.

CONDITION OF MATERIAL ON DELIVERY

5. The normal conditions of steels on delivery in different forms are stated in the individual specification in Part 2.

With certain steels special precautions after hot working are necessary and in such cases the supplier shall ensure that the condition in which the steel is supplied is satisfactory.

Bright bars shall be machined, ground, bright reeled, cold drawn, cold rolled or cold rectified as ordered. The margins of manufacture shall be in accordance with those given in Tables 8-13 (Appendix B).

GENERAL DEFINITIONS

6. a. *Heat treatment and general metallurgical terms.* For the purposes of this British Standard, unless otherwise defined herein, terms shall have the meanings given in B S 2094. 'Glossary of terms relating to iron and steel'.

b. *Yield stress.* Yield stress is the stress (load divided by the original area of cross section of a test piece) at which extension of the test piece first increases without increase of load.

With materials which have a definite yield point, when the load is increased at a uniform rate a sudden permanent increase occurs in the length of the test piece. This increase can be detected by the use of dividers, by a distinct drop of the testing machine lever or, in indicating machines, by a hesitation in the movement of the indicating pointer. It frequently happens especially with steels of tensile strengths over 50 tons/sq. in that the yield point is ill-defined and in such cases the yield stress shall be interpreted as the 0.5 per cent proof stress.

For the steels covered by the present specifications values for the yield stress are quoted in italics. These values are considered to be representative for the steels concerned but are not to be used as acceptance values except by special arrangement between the purchaser and the manufacturer.

c. *Proof stress.* Proof stress is the stress (load divided by the original area of cross section of a test piece) which produces, while the load is still applied, a non-proportional elongation equal to a specified percentage of the original gauge length. In specifying or describing a proof stress the non-proportional elongation should be quoted, e.g. 0.2 per cent proof stress or 0.5 per cent proof stress.

It can be determined from the load-elongation curve by drawing a line parallel to the straight portion of the curve distant from it by an amount representing the required non-proportional elongation, thus determining the load at which the line cuts the curve.

Alternatively, if the specification requires only a minimum value of the proof stress the material shall be deemed to be satisfactory if it passes a proving test for permanent set stress; that is, when the specified proof stress is applied to the test piece for a period of ten seconds and removed, the test piece shall not have acquired a permanent elongation greater than the specified percentage of the gauge length.

PROVISION OF MATERIAL FOR TESTING

7. a. *Definitions.*

(i) *Test sample.* A test sample is that portion of the material selected for testing.

(ii) *Test bar.* A test bar is the test sample after preparation for heat treatment.

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(iii) *Test piece.* A test piece is the test sample or test bar as finally prepared for testing.

b. Preparation of test bars. Unless otherwise specified, test samples and test bars shall be selected and prepared as follows:—The test bar shall be of sufficient length to allow of the preparation of the test pieces as specified in Clause 8 and the appropriate heat treatment shall be carried out before preparation of the test pieces, except when the specified minimum tensile strength is 85 tons/sq. in. or more. In such cases the test piece shall be machined to test piece size, plus a grinding allowance if required, before heat treatment, and the properties then obtained are representative of those of parts heat treated in the same ruling section as that of the test piece and may not represent larger ruling sections.

c. Steels other than case hardening steels.

(i) *Bars or billets for forging and bars for machining not supplied in the finally heat treated condition.*

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

Unless otherwise agreed, one tensile test and, if specified, one impact test, shall be taken from any batch of bars or billets of similar ruling section from the same cast and, for the purpose of subsequent orders, these tests shall be taken as representing all sizes of bars or billets from the same cast where the ruling section of the forgings or parts does not exceed the ruling section of the test bar already tested.

(ii) *Forgings, drop forgings and machined parts.* For forgings and drop forgings with a ruling section equivalent to a diameter greater than 1½ in., integral test samples may be provided by agreement between the purchaser and the supplier, when a prolongation shall be left on an agreed proportion of forgings or drop forgings. Unless otherwise agreed, the prolongation shall have a diameter approximately equal to the ruling section of the forging or drop forging at the time of heat treatment, and it shall not be finally severed until after heat treatment.

Where integral test samples are not required, and for small forgings and drop forgings with ruling section equivalent to a diameter of 1½ in.

or less and also for parts machined from bar not finally heat treated, separate test samples, which may be additional forgings, drop forgings or parts, shall be provided from the bars or billets from which the forgings, drop forgings or parts are made. They shall be forged and/or machined to the ruling section of the forgings, drop forgings or parts and shall be heat treated with the material they represent. The number of tests shall be agreed between the purchaser and the supplier.

(iii) *Bars for machining supplied in the finally heat treated condition.* The test samples shall be cut from the bars and shall not be further heat treated or mechanically worked after their removal except where the specified minimum tensile strength is 85 tons/sq. in. or more when test pieces shall be separately prepared as specified in Clause 7(b).

Unless otherwise agreed, the number of tensile and impact tests on any batch of bars of similar size, from the same cast and heat treated together shall be 2 per cent. of the number of bars.

If Brinell hardness tests are required by the purchaser, this shall be stated in the order, when the proportion of bars tested shall, unless otherwise agreed, be not less than 10 per cent. of the number of bars from each cast in each heat treatment batch.

(d) *Case hardening steels.* Where the size of the test sample is greater than 1½ in. diameter, separate test bars shall be prepared by forging and/or machining to that size; but for smaller sizes the test bar shall be heat treated in the full section of the sample. When the test sample is smaller than 1½ in. diameter the mechanical properties obtained may differ from those stated in the individual specification to an extent which can be determined by comparative tests on the test sample and on a test bar 1½ in. diameter from the same cast.

For bars and billets the test bars shall be carburised or blank carburised and then refined and hardened as specified in the individual specification, except that by agreement between the purchaser and the manufacturer carburising or blank carburising may be omitted (see Appendix A)

Unless otherwise agreed one tensile test and, if specified, one impact test, shall be taken from any batch of bars or billets from the same cast and for the purpose of subsequent orders the tests shall be accepted as representing all bars or billets from that cast.

For forgings, drop forgings and parts, carburisation of the test bars may be omitted but the heat treatment otherwise shall be carried out with the forgings, drop forgings or parts they represent. The number of tests shall be agreed between the purchaser and the manufacturer.

LOCATION OF TEST PIECES

8. Unless otherwise specified test pieces shall be prepared as follows:—

a. For ruling sections up to and including 1½ in. the test pieces shall be machined co-axially from the test bars.

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b For ruling sections over $1\frac{1}{8}$ in. and up to and including $2\frac{1}{4}$ in. the longitudinal axes of the test pieces shall be parallel to and not less than $\frac{9}{16}$ in. from the surface of the test bars

c For ruling sections over $2\frac{1}{4}$ in. the longitudinal axes of the test pieces shall lie midway between the axis and the surface of the test bars.

Where test material is heat treated in test piece size (see Clause 7 *b*) the above provisions need not apply.

MECHANICAL TESTS

9. *a. Tensile test.* The tensile test shall be carried out in accordance with the requirements of B.S. 18 'Tensile testing of metals.'

(i) Except as provided in (ii) below tensile test pieces shall be machined from bars, billets, forgings and drop-forgings to the dimensions of British Standard test piece C, or if the test bar is too small, to the dimensions of the largest recommended round subsidiary test piece that can be obtained (see Appendix D) having a gauge length equal to four times the square root of the area of cross section.

(ii) When permitted by the individual specification in Part 2 or for material not greater than $\frac{5}{8}$ in. diameter or width across flats, unmachined test pieces with a gauge length equal to four times the square root of the area of the area of cross section may be used.

b. Izod impact test. The Izod impact test shall be carried out in accordance with the requirements of B.S. 131 'Forms of notched bar test pieces' (See Figs. 3 to 9, Appendix D).

c. Hardness tests. The hardness test shall be carried out either in accordance with B.S. 240 'Methods and tables for Brinell hardness' using, where possible, a 10 mm diameter ball, and a load of 3000 kg.; or in accordance with B.S. 427 'Tables of diamond pyramid hardness numbers.' The equivalence between Brinell hardness numbers and diamond pyramid hardness numbers as adopted in B.S. 860 'Table of approximate comparison of hardness scales' shall be accepted.

The Brinell hardness numbers quoted in italics in Part 2 are calculated values based on the specified tensile strengths. They are for information only and are not a contractual part of the specifications.

Where the hardness number is required as an indication of uniformity, the hardness of the tensile test piece should be determined and the ratio, obtained by dividing the tensile strength by the Brinell hardness number, should be used to calculate the hardness range equivalent to the desired tensile range.

d. Transverse properties. The values quoted for mechanical properties refer to longitudinal tests. The elongation and Izod impact values obtained from transverse tests will be lower to an extent governed by the

size, form and type of steel. Where transverse tests are required, suitable values should be agreed between the purchaser and the manufacturer

RETESTS

10. Should any of the original test pieces fail to pass the mechanical tests two further samples shall be selected for retest, one of which shall be taken from the bar, billet, forging or drop forging from which the original test sample was taken, unless that item has been withdrawn by the manufacturer.

The mechanical properties obtained from the test pieces prepared from the two further test samples as stated in the appropriate general clauses shall comply with the specified requirements. Should either of the retests fail, the material represented shall be liable to rejection.

In the case of material supplied in the heat treated condition the manufacturer shall have the right to re-heat treat the material and re-submit it for inspection and testing.

INSPECTION

11. The purchaser or his representative shall have access to the works of the manufacturer at all reasonable times and shall be at liberty to inspect the manufacture and testing at any stage.

TESTING FACILITIES

12. The manufacturer shall supply free of charge the material required for testing and shall, at his own cost, furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out on his premises in accordance with this British Standard. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the test elsewhere.

REFERENCE SYMBOLS FOR TENSILE RANGES OF HARDENED AND TEMPERED MATERIAL

The varying tensile ranges for the different specifications have been designated with the letters P to Z so that the same letters always represent the same lower limit of the tensile range. The symbols are as follows:—

Reference symbol	Tensile strength (tons/sq in.)	Reference symbol	Tensile strength (tons/sq in.)
P	35	V	65
Q	40	W	70
R	45	X	75
S	50	Y	80
T	55	Z	100
U	60		

TABLE 1. TENSILE STRENGTHS OF COLD DRAWN BARS—OTHER THAN FREE-CUTTING STEELS

Specifica- tion	Chemical composition, per cent							Tensile strength (minimum unless a range is indicated)	Size (diameter or width across flats)
	C	Si	Mn	Ni	Cr	S	P		
En 3B	0.25 max.	0.35 max.	1.00 max.	—	—	0.060 max.	0.060 max.	28	in.
En 3D	0.15/0.25	0.05/0.35	0.60/1.00	—	—	0.060 max.	0.060 max.	35 30 28	1½ and less Over 1½ to 2½ Over 2½
En 4A	0.30 max.	0.05/0.35	1.00 max.	—	—	0.060 max.	0.060 max.	32/42	2 and less
En 5D*	0.25/0.35	0.05/0.35	0.60/1.00	—	—	0.060 max.	0.060 max.	45 40 35	½ and less Over ½ to ¾ Over ¾ to 2½
En 6 and En 6A	0.35 max.	0.05/0.35	0.50/0.90	—	—	0.060 max.	0.060 max.	38/48 35/45 32/45	¾ and less Over ¾ to 2½ Over 2½
En 6K	0.35 max.	0.05/0.35	0.50/0.90	—	—	0.050 max.	0.050 max.	38/48 35/45 32/45	¾ and less Over ¾ to 2½ Over 2½

* Hardened and tempered prior to cold drawing.

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TABLE 1. TENSILE STRENGTHS OF COLD DRAWN BARS—OTHER THAN FREE-CUTTING STEELS (contd.)

Specifica- tion	Chemical composition, per cent							Tensile strength (minimum unless a range is indicated)	Size (diameter or width across flats)
	C	Si	Mn	Ni	Cr	S	P		
En 8	0.35/0.45	0.05/0.35	0.60/1.00	—	—	0.060 max.	0.060 max.	42 39 37	in. 1½ and less Over 1½ to 2½ Over 2½
En 43A	0.45/0.55	0.05/0.35	0.70/1.00	—	—	0.060 max.	0.060 max.	45/60	2 and less
En 14A	0.15/0.25	0.10/0.35	1.30/1.70	0.40 max.	0.25 max.	0.060 max.	0.060 max.	45	2 and less
En 14B	0.20/0.30	0.10/0.35	1.30/1.70	0.40 max.	—	0.060 max.	0.060 max.	45	2 and less
En 9	0.50/0.60	0.05/0.35	0.50/0.80	—	—	0.060 max.	0.060 max.	50/65	2 and less
En 9K	0.50/0.60	0.05/0.35	0.50/0.80	—	—	0.050 max.	0.050 max.	50/65	2 and less

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TABLE 2. TENSILE STRENGTHS OF COLD DRAWN FREE-CUTTING STEEL BARS

Specification	Chemical composition, per cent					Tensile strength (minimum unless a range is indicated)	Size (diameter or width across flats)
	C	Si	Mn	S	P		
En 1A	0.07/0.15	0.10 max.	0.80/1.20	0.20/0.30	0.070 max.	tons/sq. in.	in.
						32	$1\frac{1}{32}$ and less
						28	Over $1\frac{1}{32}$ to $1\frac{1}{2}$
						25	Over $1\frac{1}{2}$ to $2\frac{1}{2}$
23	Over $2\frac{1}{2}$ to 4						
En 1B	0.07/0.15	0.10 max.	1.00/1.40	0.30/0.60	0.060 max.	27	$1\frac{1}{32}$ and less
						25	Over $1\frac{1}{32}$ to $1\frac{1}{2}$
						23	Over $1\frac{1}{2}$ to $2\frac{1}{2}$
							Over $2\frac{1}{2}$ to 4
En 7	0.10/0.30	0.25 max.	0.70/1.30	0.10/0.18	0.060 max.	40/50	$\frac{1}{2}$ and less
						35/45	Over $\frac{1}{2}$ to $1\frac{3}{4}$
						30/40	Over $1\frac{3}{4}$ to $2\frac{1}{2}$
En 7A	0.12/0.18	0.25 max.	1.00/1.50	0.10/0.18	0.060 max.	35/45	$1\frac{1}{8}$ and less
						30/40	Over $1\frac{1}{8}$ to $2\frac{1}{8}$
En 8M	0.35/0.45	0.25 max.	0.90/1.30	0.12/0.20	0.060 max.	38	$1\frac{1}{2}$ and less

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TABLE 3. TENSILE STRENGTHS OF HOT ROLLED OR NORMALISED BARS, BILLETS, FORGINGS AND DROP FORGINGS—OTHER THAN FREE-CUTTING STEELS

Specifica- tion	Chemical composition, per cent							Tensile strength (minimum unless a range is indicated)	Limiting ruling section
	C	Si	Mn	Ni	Cr	S	P		
En 2	0.20 max.	—	0.80 max.	—	—	0.060 max.	0.060 max.	tons/sq. in. 20	in. 6
En 2E	0.15 max.	0.10/0.35	0.50 max.	—	—	0.050 max.	0.050 max.	20	6
En 3	0.25 max.	0.05/0.35	1.00 max.	—	—	0.060 max.	0.060 max.	25/35	6
En 3A	0.15/0.25	0.05/0.35	0.40/0.90	—	—	0.060 max.	0.060 max.	28	6
En 3C	0.17/0.23	0.05/0.35	0.60/1.00	—	—	0.050 max.	0.050 max.	28	6
En 4	0.30 max.	0.05/0.35	1.00 max.	—	—	0.060 max.	0.060 max.	28/38	6
En 5	0.25/0.35	0.05/0.35	0.60/1.00	—	—	0.060 max.	0.060 max.	32	2½
En 5K	0.25/0.35	0.05/0.35	0.60/1.00	—	—	0.050 max.	0.050 max.	32	2½
En 6 and En 6A	0.40 max.	0.05/0.35	0.50/0.90	—	—	0.060 max.	0.060 max.	38/48 35/45 32/45	¾ 2½ 6
En 6K	0.40 max.	0.05/0.35	0.50/0.90	—	—	0.050 max.	0.050 max.	38/48 35/45 32/45	¾ 2½ 6

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TABLE 3. TENSILE STRENGTHS OF HOT ROLLED OR NORMALISED BARS, BILLETS, FORGINGS AND DROP FORGINGS—OTHER THAN FREE CUTTING STEELS (contd.)

Specifica- tion	Chemical composition, per cent							Tensile strength (minimum unless a range is indicated)	Limiting ruling section
	C	Si	Mn	Ni	Cr	S	P		
En 8	0.35/0.45	0.05/0.35	0.60/1.00	—	—	0.060 max.	0.060 max.	tons/sq. in. 35	in. 6
En 8K	0.35/0.45	0.05/0.35	0.60/1.00	—	—	0.050 max.	0.050 max.	35	6
En 12	0.30/0.45	0.10/0.35	1.50 max.	0.60/1.00	—	0.050 max.	0.050 max.	35	6
En 14A	0.15/0.25	0.10/0.35	1.30/1.70	0.40 max.	0.25 max.	0.060 max.	0.060 max.	35	6
En 14A/1*	0.23 max.	0.05/0.35	1.20 min.	—	—	0.060 max.	0.060 max.	35/41 33/39	1½ 2½
En 14B	0.20/0.30	0.10/0.35	1.30/1.70	0.40 max.	—	0.060 max.	0.060 max.	33	5
En 43A	0.45/0.55	0.05/0.35	0.70/1.00	—	—	0.060 max.	0.060 max.	40	1½
En 9	0.50/0.60	0.05/0.35	0.50/0.80	—	—	0.060 max.	0.060 max.	45	4
En 9K	0.50/0.60	0.05/0.35	0.50/0.80	—	—	0.050 max.	0.050 max.	45	4

* C₁ (optional) 0.60 max. Mn + residual Ni, Cr and Mo, 2.0 per cent max.

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TABLE 4. TENSILE STRENGTHS OF HARDENED AND TEMPERED

The mechanical properties specified are obtainable

Spec.	Type of steel	Chemical composition, per cent					
		C	Si	Mn	Ni	Cr	Mo
En 5 (a)	'30' carbon	0.25/0.35	0.05/0.35	0.60/1.00	—	—	—
En 5K	'50' carbon	0.25/0.35	0.05/0.35	0.60/1.00	—	—	—
En 8 (a)	'40' carbon	0.35/0.45	0.05/0.35	0.60/1.00	—	—	—
En 8K	'40' carbon	0.35/0.45	0.05/0.35	0.60/1.00	—	—	—
En 8M (b)	'40' carbon-free cutting	0.35/0.45	0.25 max.	0.90/1.30	—	—	—
En 43A (a)	'50' carbon	0.45/0.55	0.05/0.35	0.70/1.00	—	—	—
En 9 (a)	'55' carbon	0.50/0.60	0.05/0.35	0.50/0.80	—	—	—
En 9K	'55' carbon	0.50/0.60	0.05/0.35	0.50/0.80	—	—	—
En 14A (a)	Carbon-manganese	0.15/0.25	0.10/0.35	1.30/1.70	0.40 max	0.25 max	—
En 14B (a)	Carbon-manganese	0.20/0.30	0.10/0.35	1.30/1.70	0.40 max	—	—
En 15A (a)	Carbon-manganese (higher tensile)	0.30/0.40	0.05/0.35	1.30/1.70	—	—	—
En 15AM (b)	Carbon-manganese free cutting	0.30/0.40	0.25 max	1.30/1.70	—	—	—
En 15B (a)	Carbon-manganese (higher tensile)	0.35/0.40	0.05/0.35	1.10/1.30	—	—	—

S 0.050 max. and P 0.050 max in all cases except .

a S 0.060 max, P 0.060 max and

b S 0.12/0.20, P 0.060 max.

BAR, BILLETS, FORGINGS AND DROP FORGINGS

within the limits of ruling section given below.

P	Q	R	S	T	U	V	W	X & Y	Z
35/45 tons/ sq. in. tensile	40/50 tons/ sq. in. tensile	45/55 tons/ sq. in. tensile	50/60 tons/ sq. in. tensile	55/65 tons/ sq. in. tensile	60/70 tons/ sq. in. tensile	65/75 tons/ sq. in. tensile	70/80 tons/ sq. in. tensile	75/85 and 80/90 tons/ sq. in. tensile	100 tons/sq. in. min. tensile
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
2½	¾	¾	—	—	—	—	—	—	—
—	2½	¾	—	—	—	—	—	—	—
—	2½	—	—	—	—	—	—	—	—
—	2	¾	—	—	—	—	—	—	—
—	—	2	1½	—	—	—	—	—	—
—	—	2	1½	1½	—	—	—	—	—
—	—	2	1½	1½	—	—	—	—	—
—	4	1½	—	—	—	—	—	—	—
—	4	2½	—	—	—	—	—	—	—
—	4	2½	¾	—	—	—	—	—	—
—	—	2½	—	—	—	—	—	—	—
—	4	2½	¾	¾	—	—	—	—	—

TABLE 4. TENSILE STRENGTHS OF HARDENED AND TEMPERED
The mechanical properties specified are obtainable

Spec.	Type of steel	Chemical composition, per cent					
		C	Si	Mn	Ni	Cr	Mo
En 15	Carbon-manganese (higher tensile)	0.30/0.40	0.10/0.35	1.30/1.70	—	—	—
En 12	1 per cent nickel	0.30/0.45	0.10/0.35	1.50 max.	0.60/1.00	—	—
En 13	Manganese-nickel-molybdenum	0.15/0.25	0.10/0.35	1.40/1.80	0.40/0.70	—	0.15/0.35
En 18	1 per cent chromium	0.35/0.45	0.10/0.35	0.60/0.95	—	0.85/1.15	—
En 21	3 per cent nickel	0.25/0.35	0.10/0.35	0.35/0.75	2.75/3.25	0.30 max.	—
En 16 and En 16D	Manganese-molybdenum	0.30/0.40	0.10/0.35	1.30/1.80	—	—	0.20/0.35
		0.25/0.35	0.10/0.35	1.30/1.80	—	—	0.20/0.35
En 19A	1 per cent chromium-molybdenum	0.35/0.45	0.10/0.35	0.50/0.80	—	0.90/1.20	0.20/0.35
En 100 and En 100E	Low alloy	0.35/0.45	0.50 max.	1.20/1.50	0.50/1.00	0.30/0.60	0.15/0.25
		0.25/0.35	0.50 max.	1.20/1.50	0.50/1.00	0.30/0.60	0.15/0.25
En 111	Low nickel-chromium	0.30/0.40	0.10/0.35	0.60/0.90	1.00/1.50	0.45/0.75	—
En 160	2 per cent nickel-molybdenum	0.35/0.45	0.10/0.35	0.30/0.60	1.50/2.00	—	0.20/0.35
En 22	3½ per cent nickel	0.35/0.45	0.10/0.35	0.50, 0.80	3.25/3.75	0.30 max.	—
En 11	'60' carbon-chromium	0.50/0.70	0.10/0.35	0.50/0.80	—	0.50/0.80	—
En 17	Manganese-molybdenum (higher molybdenum)	0.30/0.40	0.10/0.35	1.30/1.80	—	—	0.35/0.55

S 0.050 max and P 0.030 max in all cases.

BARS, BILLETS, FORGINGS AND DROP FORGINGS (contd.)
within the limits of ruling section given below

P	Q	R	S	T	U	V	W	X & Y	Z
35/45 tons/sq. in. tensile	40/50 tons/sq. in. tensile	45/55 tons/sq. in. tensile	50/60 tons/sq. in. tensile	55/65 tons/sq. in. tensile	60/70 tons/sq. in. tensile	65/75 tons/sq. in. tensile	70/80 tons/sq. in. tensile	75/85 and 80/90 tons/sq. in. tensile	100 tons/sq. in. min. tensile
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
—	6	2½	¾	—	—	—	—	—	—
—	6	—	—	—	—	—	—	—	—
—	6	—	—	—	—	—	—	—	—
—	—	4	2½	1½	—	—	—	—	—
—	—	4	2½	—	—	—	—	—	—
—	—	6	4	2½	1½	¾	—	—	—
—	—	6	4	2½	1½	¾	—	—	—
—	—	6	4	2½	1½	¾	—	—	—
—	—	—	4	2½	—	—	—	—	—
—	—	—	—	2½	—	2½	—	—	—
—	—	6	6	4	2½	1½	—	—	—

TABLE 4. TENSILE STRENGTHS OF HARDENED AND TEMPERED
The mechanical properties specified are obtainable

Spec.	Type of steel	Chemical composition, per cent					
		C	Si	Mn	Ni	Cr	Mo
En 19	1 per cent chromium-molybdenum	0.35/0.45	0.10/0.35	0.50/0.80	—	0.90/1.50	0.20/0.40
En 20A and En 20B	1 per cent chromium-molybdenum (higher molybdenum)	0.20/0.30	0.10/0.35	0.40/0.70	—	0.50/1.00	0.50/0.80
		0.35/0.45	0.10/0.35	0.40/0.70	—	1.00/1.50	0.50/0.90
En 110	Low nickel-chromium-molybdenum	0.35/0.45	0.10/0.35	0.40/0.80	1.20/1.60	0.90/1.40	0.10/0.20
En 24	1½ per cent nickel-chromium-molybdenum	0.35/0.45	0.10/0.35	0.45/0.70	1.30/1.80	0.90/1.40	0.20/0.35
En 23	3 per cent nickel-chromium	0.25/0.35	0.10/0.35	0.45/0.70	2.75/3.50	0.50/1.00	0.65 max. (optional)
En 29A and En 29B	3 per cent chromium-molybdenum	0.15/0.25	0.10/0.35	0.65 max.	0.40 max.	2.50/3.50	0.30/0.70
		0.25/0.35	0.10/0.35	0.65 max.	0.40 max.	2.50/3.50	0.30/0.70
En 25	2½ per cent nickel-chromium-molybdenum (medium carbon)	0.27/0.35	0.10/0.35	0.50/0.70	2.30/2.80	0.50/0.80	0.40/0.70
En 27	3 per cent nickel-chromium-molybdenum	0.25/0.35	0.10/0.35	0.70 max.	3.00/3.75	0.50/1.30	0.20/0.65
En 28	3½ per cent nickel-chromium-molybdenum	0.25/0.40	0.10/0.35	0.70 max.	3.00/4.50	0.75/1.50	0.20/0.65
En 26	2½ per cent nickel-chromium-molybdenum (high carbon)	0.36/0.44	0.10/0.35	0.50/0.70	2.30/2.80	0.50/0.80	0.40/0.70
En 30A and En 30B	4½ per cent nickel-chromium and 4½ per cent nickel-chromium-molybdenum	0.26/0.34	0.10/0.35	0.40/0.60	3.90/4.30	1.10/1.40	—
		0.26/0.34	0.10/0.35	0.40/0.60	3.90/4.30	1.10/1.40	0.20/0.40

S 0.050 max. and P 0.050 max. in all cases.

BARS, BILLETS, FORGINGS AND DROP FORGINGS (contd.)
within the limits of ruling section given below.

P	Q	R	S	T	U	V	W	X & Y	Z
35/45 tons/sq. in. tensile	40/50 tons/sq. in. tensile	45/55 tons/sq. in. tensile	50/60 tons/sq. in. tensile	55/65 tons/sq. in. tensile	60/70 tons/sq. in. tensile	65/75 tons/sq. in. tensile	70/80 tons/sq. in. tensile	75/85 and 80/90 tons/sq. in. tensile	100 tons/sq. in. min. tensile
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
—	—	6	4	2½	2½	1½	1½	1 (Y)	—
—	—	—	—	2½	2½	1½	—	—	—
—	—	—	6	4	2½	1½	1½	—	—
—	—	—	6	6	4	2½	1½	1½	1½ if oil hardened
—	—	—	6	6	6	2½	—	—	—
—	—	6	6	6	6	4	4	—	2½ if oil hardened
—	—	—	—	6	6	6	4	2½	2½ if oil hardened
—	—	—	—	6	6	6	4	—	—
—	—	—	—	—	6	6	4	2½	—
—	—	—	—	—	6	6	6	6	4 if oil hardened
—	—	—	—	—	—	—	—	—	2½ if air hardened ; 6 if oil hardened

TABLE 5. TENSILE STRENGTHS OF HARDENED AND TEMPERED BARS
The mechanical properties specified are obtainable

Spec.	Type of steel	Chemical composition, per cent					
		C	Si	Mn	Ni	Cr	Mo
En 40A and En 40B	3 per cent chromium- molybdenum	0.10/0.20	0.10/0.35	0.40/0.65	0.40 max.	2.90/3.50	0.40/0.70
		0.20/0.30	0.10/0.35	0.40/0.65	0.40 max.	2.90/3.50	0.40/0.70
En 41A and En 41B	1½ per cent chromium- aluminium- molybdenum	0.25/0.35	0.10/0.45	0.65 max.	0.40 max.	1.40/1.80	0.10/0.25
		0.35/0.45	0.10/0.45	0.65 max.	0.40 max.	1.40/1.80	0.10/0.25
En 40C	3 per cent chromium- molybdenum- vanadium	0.30/0.50	0.10/0.35	0.40/0.80	0.40 max.	2.50/3.50	0.70/1.20

BILLETS, FORGINGS AND DROP FORGINGS—NITRIDING STEELS
within the limits of ruling section given below.

V	Al	S	P	R	S	T	U	-
				45/55 tons/ sq. in. tensile	50/60 tons/ sq. in. tensile	55/65 tons/ sq. in. tensile	60/70 tons/ sq. in. tensile	85 (tons/ sq. in. min. tensile
—	—	0.050 max.	0.050 max.	in.	in.	in.	in.	in.
—	—	0.050 max.	0.050 max.	6	6	6	6	—
—	0.90/1.30	0.050 max.	0.050 max.	6	4	2½	—	—
—	0.90/1.30	0.050 max.	0.050 max.					
0.10/0.30	—	0.050 max.	0.050 max.	—	—	—	—	2½

TABLE 6. TENSILE STRENGTHS OF THE
(Tested on 1 1/8 in.

Specification	Type of steel	Chemical		
		C	SI	Mn
En 32A	Carbon	0.15 max.	0.05/0.35	0.40/0.70
En 32B	Carbon	0.10/0.18	0.05/0.35	0.60/1.00
En 32C	Carbon	0.10/0.18	0.05/0.35	0.60/1.00
En 32M	Carbon (semi-free cutting)	0.10/0.18	0.05/0.35	0.90/1.20
En 202	Carbon-manganese (semi-free cutting)	0.18 max.	0.05/0.35	1.20/1.50
En 37	5 per cent nickel	0.16 max.	0.10/0.35	0.45 max.
En 201	Carbon-manganese	0.18 max.	0.05/0.35	1.10/1.50
En 33	3 per cent nickel	0.10/0.15	0.10/0.35	0.30/0.60
En 34	2 per cent nickel-molybdenum (lower carbon)	0.14/0.20	0.10/0.35	0.30/0.60
En 351	3/4 per cent nickel-chromium	0.20 max.	0.35 max.	0.60/1.00
En 361	'15' carbon low alloy	0.13/0.17	0.35 max.	0.70/1.00
En 35	2 per cent nickel-molybdenum (higher carbon)	0.20/0.28	0.10/0.35	0.30/0.60
En 36A	3 per cent nickel-chromium	0.15 max.	0.10/0.35	0.30/0.60
En 325	Low nickel-chromium-molybdenum	0.22 max.	0.10/0.35	0.45/0.65
En 352	1 per cent nickel-chromium	0.20 max.	0.35 max.	0.50/1.00
En 362	'20' carbon low alloy	0.18/0.23	0.35 max.	0.70/1.00
En 36B	3 per cent nickel-chromium	0.12/0.18	0.10/0.35	0.30/0.60
En 36C	3 per cent nickel-chromium-molybdenum	0.12/0.18	0.10/0.35	0.30/0.60
En 38	5 per cent nickel-molybdenum	0.16 max.	0.10/0.35	0.60 max.
En 353	1 1/4 per cent nickel-chromium	0.20 max.	0.35 max.	0.50/1.00
En 363	'25' carbon low alloy	0.22/0.26	0.35 max.	0.70/1.00
En 354	1 3/4 per cent nickel-chromium-molybdenum	0.20 max.	0.35 max.	0.50/1.00
En 39A	4 1/4 per cent nickel-chromium	0.12/0.18	0.10/0.35	0.50 max.
En 39B	4 1/4 per cent nickel-chromium-molybdenum	0.12/0.18	0.10/0.35	0.50 max.
En 355	2 per cent nickel-chromium-molybdenum (low chromium)	0.20 max.	0.35 max.	0.40/0.70

CORES OF CASE-HARDENED STEELS
diameter bars)

composition, per cent					Tensile strength, min. tons/sq. in.	Izod impact value, min. ft. lb.
Ni	Cr	Mo	S	P		
—	—	—	0.050 max.	0.050 max.	32	40
—	—	—	0.070 max.	0.050 max.	32	40
—	—	—	0.050 max.	0.050 max.	32	40
—	—	—	0.10/0.15	0.050 max.	32	40
—	—	—	0.10/0.18	0.050 max.	38	30
4.50/5.20	0.30 max.	—	0.050 max.	0.050 max.	40	50
—	—	—	0.050 max.	0.050 max.	40	40
2.75/3.50	0.30 max.	—	0.050 max.	0.050 max.	45	40
1.50/2.00	—	0.20/0.30	0.050 max.	0.050 max.	45	40
0.60/1.00	0.40/0.80	0.10 max.	0.050 max.	0.050 max.	45	30
0.40/0.70	0.55/0.80	0.08/0.15	0.050 max.	0.050 max.	45	25
1.50/2.00	—	0.20/0.30	0.050 max.	0.050 max.	55	22
3.00/3.75	0.60/1.10	—	0.050 max.	0.050 max.	55	35
1.50/2.00	0.40/0.60	0.20/0.30	0.050 max.	0.050 max.	55	30
0.85/1.25	0.60/1.00	0.10 max.	0.050 max.	0.050 max.	55	20
0.40/0.70	0.55/0.80	0.08/0.15	0.050 max.	0.050 max.	55	15
3.00/3.75	0.60/1.10	—	0.050 max.	0.050 max.	65	30
3.00/3.75	0.60/1.10	0.10/0.25	0.050 max.	0.050 max.	65	30
4.50/5.50	0.30 max.	0.15/0.30	0.050 max.	0.050 max.	65	30
1.00/1.50	0.75/1.25	0.08/0.15	0.050 max.	0.050 max.	65	20
0.40/0.70	0.55/0.80	0.08/0.15	0.050 max.	0.050 max.	65	—
1.50/2.00	0.75/1.25	0.10/0.20	0.050 max.	0.050 max.	75	20
3.80/4.50	1.00/1.40	—	0.050 max.	0.050 max.	85	25
3.80/4.50	1.00/1.40	0.15/0.35	0.050 max.	0.050 max.	85	25
1.80/2.20	1.40/1.70	0.15/0.25	0.050 max.	0.050 max.	85	25

TABLE 7. SUMMARY OF SPRING STEEL BARS

Specification	Type of steel	Chemical composition, per cent						
		C	Si	Mn	Cr	V	S	P
En 42	Carbon—for oil hardening	0.70/ 0.85	0.10/ 0.40	0.55 0.75	—	—	0.050 max.	0.050 max.
En 43	Carbon—for water hardening	0.45/ 0.60	0.10/ 0.40	0.60/ 0.80	—	—	0.050 max.	0.050 max.
En 44	Carbon (higher carbon)—for oil hardening	0.90/ 1.20	0.30 max.	0.45/ 0.70	—	—	0.050 max.	0.050 max.
En 45	Silicon-manganese—for oil hardening	0.50/ 0.60	1.50/ 2.00	0.70/ 1.00	—	—	0.050 max.	0.050 max.
En 45A	Silicon-manganese—for oil hardening	0.55/ 0.65	1.70/ 2.00	0.70/ 1.00	—	—	0.050 max.	0.050 max.
En 46	Silicon-manganese—for water hardening	0.35/ 0.45	1.50/ 2.00	0.70/ 1.00	—	—	0.050 max.	0.050 max.
En 47	1 per cent chromium-vanadium—for oil hardening	0.45/ 0.55	0.50 max.	0.50/ 0.80	0.80/ 1.20	0.15 min.	0.050 max.	0.050 max.
En 48	1 per cent chromium—for oil hardening	0.45/ 0.55	0.10/ 0.50	0.50/ 0.80	1.00/ 1.40	—	0.050 max.	0.050 max.
En 48A	Silicon-chromium—for oil hardening	0.50/ 0.60	1.35/ 1.65	0.60/ 0.90	0.55/ 0.85	—	0.050 max.	0.050 max.

PART 2

SPECIFIC REQUIREMENTS

PART 2

SPECIFIC REQUIREMENTS

FREE CUTTING STEEL FOR MACHINING

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.07	0.15
Silicon	—	0.10
Manganese	0.80	1.20
Sulphur	0.20	0.30
Phosphorus	—	0.070

Condition of material on delivery. The material shall be delivered in the as rolled or forged condition, unless the order states otherwise.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

AS ROLLED, NORMALISED OR BRIGHT FINISHED (OTHER THAN
COLD ROLLED OR COLD DRAWN)

Limiting ruling section, in.	4
Tensile strength, tons/sq. in., min.	23
Elongation, per cent, min.	26

COLD ROLLED OR COLD DRAWN

Property	Size (diameter or width across flats), in.			
	$1\frac{1}{32}$ or less	Over $1\frac{1}{32}$ to $1\frac{1}{2}$	Over $1\frac{1}{2}$ to $2\frac{1}{2}$	Over $2\frac{1}{2}$ to 4
Tensile strength, tons/sq in., min.	32	28	25	23
Elongation, per cent., min.	10	14	14	14

This steel is supplied as a free cutting steel for machining. It is not supplied for case hardening and this requirement does not form part of the specification. For guidance only, a core strength of approximately 28 tons/sq in. should be expected if this steel is heat treated in accordance with the requirements of En32A.

As altered
Feb. 1963

FREE CUTTING STEEL BARS FOR MACHINING (HIGHER SULPHUR)

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.07	0.15
Silicon	—	0.10
Manganese	1.00	1.40
Sulphur	0.30	0.60
Phosphorus	—	0.060

Condition of material on delivery. Bars shall be delivered in the as rolled condition, unless the order states otherwise.

Mechanical properties. The mechanical properties obtained from test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

AS ROLLED OR BRIGHT FINISHED (OTHER THAN COLD ROLLED OR COLD DRAWN)

Limiting ruling section, in.	2½
Tensile strength, tons/sq. in., min.	23
Elongation, per cent, min.	24

COLD ROLLED OR COLD DRAWN

Property	Size (diameter or width across flats) in.		
	1⅞ ₃₂ or less	Over 1⅞ ₃₂ to 1½	Over 1½ to 2½
Tensile strength, tons/sq. in., min.	27	25	23
Elongation, per cent., min.	10	12	12

As altered Feb. 1963 This steel is supplied as a free cutting steel for machining. It is not supplied for case hardening, and this requirement does not form part of the specification. For guidance only, a core strength of approximately 28 tons/sq. in. should be expected if this steel is heat treated in accordance with the requirements of En32A.

GENERAL PURPOSE COLD FORMING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Chemical composition. The steel shall contain :

Carbon	0.20 per cent max.
Manganese	0.80 per cent max.
Sulphur	0.060 per cent max.
Phosphorus	0.060 per cent max.

Condition of material on delivery. The material shall be delivered in the as rolled or forged condition, unless the order states otherwise.

Mechanical properties. The following mechanical properties shall be obtained from the test pieces selected and prepared as stated in the appropriate general clauses. Alternatively, for bars 1 in diameter and under, by agreement between purchaser and manufacturer, tensile tests may be carried out on the full section of the bar and in such cases the elongation shall be measured on a gauge length equal to four times the square root of the area of cross section of the bar.

Limiting ruling section, in.	6
Tensile strength, tons/sq. in., min.	20
Elongation, per cent, min.	28
Bend test* (180°)	$r = \frac{1}{4} t$

NOTE When required in the form of plate, sheet and strip the steel should be ordered to B.S. 1449, 'Steel plate, sheet and strip', when the limits for manganese, sulphur and phosphorus do not apply.

* Applicable only to bars rolled or forged to a minor sectional dimension not greater than ½ in. For further information see B.S. 1639, 'Notes on the simple bend test'.

SPECIAL PURPOSE COLD FORMING STEELS

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Steel of the En 2 type may be required for special applications when it should be ordered to specification number En 2A, En 2A/1, En 2B, En 2C or En 2D. It is desirable to consult the steelmaker regarding the most satisfactory specification for the purpose.

Chemical composition. The chemical composition shall be as follows :

Element	En 2A/1	En 2A	En 2B	En 2C		En 2D	
	per cent max.	per cent max.	per cent max.	per cent		per cent	
				min.	max.	min.	max.
Carbon	0.10	0.12	0.15	0.15	0.25	0.15	0.30
Manganese	0.50	0.50	0.50	0.40	0.60	0.40	0.70
Sulphur	0.040	0.050	0.050	—	0.050	—	0.050
Phosphorus	0.040	0.050	0.050	—	0.050	—	0.050

Condition of material on delivery. The material shall be delivered in the as rolled or forged condition, unless the order states otherwise.

Mechanical properties. If required, mechanical properties shall be agreed between purchaser and manufacturer.

NOTE. When required in the form of plate, sheet and strip for deep drawing and other cold forming operations, the steels should be ordered to B S 1449, 'Steel plate, sheet and strip'

COLD FORMING STEEL (FULLY KILLED)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.15
Silicon	0.10	0.35
Manganese	—	0.50
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. The material shall be delivered in the as rolled or forged condition, unless the order states otherwise.

Mechanical properties. The following mechanical properties shall be obtained from the test pieces selected and prepared as stated in the appropriate general clauses. Alternatively, for bars 1 in diameter and under, by agreement between purchaser and manufacturer, tensile tests may be carried out on the full section of the bar, and in such cases the elongation per cent shall be measured on a gauge length equal to four times the square root of the area of cross section of the bar.

Limiting ruling section, in.	6
Tensile strength, tons/sq in., min.	20
Elongation, per cent, min.	28
Brinell hardness number, max.	120

Hardening test. When specified on the order, a test piece not exceeding ½ in. ruling section, selected as stated in the general clauses, shall be oil quenched from 1000° C. The Brinell hardness number of the quenched test piece shall not exceed 160.

'20' CARBON STEEL (HOT ROLLED OR FORGED)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Suitable for a tensile range of 25/35 tons/sq. in.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.25
Silicon	0.05	0.35
Manganese	—	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. The material shall be delivered in the as rolled or forged condition, unless the order states otherwise.

Mechanical properties. The following mechanical properties shall be obtained from the test pieces selected and prepared as stated in the appropriate general clauses. Alternatively, for bars of 1 in. diameter and under, by agreement between purchaser and manufacturer, tensile tests may be carried out on the full section of the bar, and in such cases the elongation per cent shall be measured on a gauge length equal to four times the square root of the area of cross section of the bar.

Limiting ruling section, in.	6
Tensile strength, tons/sq. in. min.	25
max.	35
Elongation, per cent, min.	25

'20' CARBON STEEL (HOT ROLLED OR NORMALISED)

En 3C is intended for special applications only

BARS AND BILLETS FOR FORGING
FORGING AND DROP-FORGINGS
BRIGHT BARS FOR MACHINING

Suitable for a tensile range of 28/33 tons/sq. in. The purchaser should state on the order the condition in which the material is required.

Chemical composition. The steel shall contain :

Element	En 3A		En 3C	
	per cent		per cent	
	min.	max.	min.	max.
Carbon	0.15	0.25	0.17	0.23
Silicon	0.05	0.35	0.05	0.35
Manganese	0.40	0.90	0.60	1.00
Sulphur	—	0.060	—	0.050
Phosphorus	—	0.060	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in one of the following conditions as the order shall state :—

- (i) Hot rolled—as rolled condition.
- (ii) Hot rolled and normalised.
- (iii) Bright finish (other than cold drawn)—as rolled condition.
- (iv) Bright drawn finished-normalised.

Heat treatment. The heat treatment to be given, where appropriate, to the test bars selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Normalise at a temperature of 880/910° C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Limiting ruling section, in.	6
Tensile strength, tons/sq. in, min.	28
Elongation, per cent, min.	25

'20' CARBON STEEL (COLD DRAWN)

BRIGHT BARS FOR MACHINING

Chemical composition. The steel shall contain :

Carbon	0.25 per cent max.
Silicon	0.35 per cent max
Manganese	1.00 per cent max.
Sulphur	0.060 per cent max.
Phosphorus	0.060 per cent max.

When so stated on the order the carbon content for bars up to and including 2½ in. diameter or width across flats shall not exceed 0.20 per cent.

Condition of material on delivery. Bars shall be delivered in the cold drawn condition.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	28
Elongation, per cent, min.	17

'20' CARBON STEEL (COLD DRAWN—HIGHER TENSILE)

BRIGHT BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.15	0.25
Silicon	0.05	0.35
Manganese	0.60	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. Bars shall be delivered in the cold drawn condition.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Size (diameter or width across flats), in.		
	1¼ or less	Over 1¼ to 2½	Over 2½
Tensile strength, tons/sq. in., min.	35	30	28
Elongation, per cent, min.	15	15	15

'25' CARBON STEEL (NORMALISED)

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP-FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS (EXCLUDING COLD DRAWN BARS)

Suitable for a tensile range of 28/38 tons/sq. in.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.30
Silicon	0.05	0.35
Manganese	—	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining and bright bars shall be delivered in the finally heat treated condition, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Normalise at a temperature of 850/900° C.

Mechanical properties. The following mechanical properties shall be obtained from the test pieces selected and prepared as stated in the appropriate general clauses. Alternatively, for bars of 1 in. diameter and under, by agreement between purchaser and manufacturer, tensile tests may be carried out on the full section of the bar, and in such cases the elongation per cent shall be measured on a gauge length equal to four times the square root of the area of cross section of the bar.

Limiting ruling section, in.	6	2½
Tensile strength, tons/sq. in.	28 min, 38 max	28 min, 38 max
Elongation, per cent, min.	25	25
Izod impact value, ft. lb, min.	—	20
Brinell hardness number	126/179	126/179

' 25 ' CARBON STEEL (COLD DRAWN)

BRIGHT BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.30
Silicon	0.05	0.35
Manganese	—	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. Bars shall be delivered in the cold drawn condition.

Mechanical properties. The following mechanical properties shall be obtained from the test pieces selected and prepared as stated in the appropriate general clauses :

Maximum size (diameter or width across flats), in.	2
Tensile strength, tons/sq. in., min.	32
	max. 42
Elongation, per cent, min.	12

Alternatively, acceptance shall be on a normalised test piece when the heat treatment and mechanical properties specified for En 4 shall apply.

'30' CARBON STEEL

En 5K is intended for special applications only

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS (EXCLUDING COLD DRAWN BARS)

En 5, 5K

Suitable, in the hardened and tempered condition, for tensile ranges of 35/45 (P), 40/50 (Q) and 45/55 (R) tons/sq. in. The purchaser should state on the order the condition, normalised or hardened and tempered, P, Q or R, for which the material is required.

Chemical composition. The steel shall contain :

Element	En 5		En 5K	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.25	0.35	0.25	0.35
Silicon	0.05	0.35	0.05	0.35
Manganese	0.60	1.00	0.60	1.00
Sulphur	—	0.060	—	0.050
Phosphorus	—	0.060	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining and bright bars shall be delivered in the finally heat treated condition, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7 and to material supplied in the finally heat treated condition shall be as follows —

a. Material required in the normalised condition :

Normalise at a temperature of 860/890°C.

b. Material required in the hardened and tempered condition :

Harden in oil or water from a temperature of 860/890°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Condition			
	Normalised	Hardened and tempered		
		P	Q	R
Limiting ruling section, in.	2½	2½	¾	¾
Tensile strength, tons/sq. in., min.	32	35	40	45
Yield stress, tons/sq. in., min.	16	22	28	32
Elongation, per cent, min.	25	22	20	20
Izod impact value, ft. lb., min.	20	20	20	40
Brinell hardness number	143/193	152/207	179/229	201/255

NOTE 1 Steel to En 5K shall comply with the following requirements when proof stress tests are specifically requested in the enquiry and order :—

Property	Condition		
	P	Q	R
Proof stress (0.2 per cent) tons/sq. in., min.	20	26	30

NOTE 2. When steel to En 5 is required in the form of plate, sheet and strip it should be ordered to B.S. 1449, 'Steel plate, sheet and strip'.

For special applications steel of this type may be ordered to specifications En 5A, En 5B, En 5C, when it will be supplied to a specified composition only, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 5A, En 5B and En 5C.

Element	En 5A		En 5B		En 5C	
	Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.
Carbon	0.25	0.30	0.28	0.33	0.30	0.35
Silicon	0.05	0.35	0.05	0.35	0.05	0.35
Manganese	0.70	0.90	0.70	0.90	0.70	0.90
Sulphur	—	0.060	—	0.060	—	0.060
Phosphorus	—	0.060	—	0.060	—	0.060

'30' CARBON STEEL (HARDENED, TEMPERED, AND BRIGHT DRAWN)

BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.25	0.35
Silicon	0.05	0.35
Manganese	0.60	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. Bars shall be delivered in the hardened tempered and bright drawn condition.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Size (diameter or width across flats), in.			
	½ or less	Over ½ to ¾	Over ¾ to 1½	Over 1½ to 2½
Tensile strength, tons/sq. in., min.	45	40	35	35
Elongation, per cent, min.	20	18	15	15
Izod impact value, ft. lb., min.	40	20	15	10
Brinell hardness number, max.	255	229	229	229

BRIGHT CARBON STEEL

En 6K is intended for special applications only

BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	En 6		En 6K	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	—	0.40*	—	0.40*
Silicon	0.05	0.35	0.05	0.35
Manganese	0.50	0.90	0.50	0.90
Sulphur	—	0.060	—	0.050
Phosphorus	—	0.060	—	0.050

En 6, 6K

*For bars supplied in the cold drawn condition the carbon content shall not exceed 0.35 per cent

Condition of material on delivery. The bars shall be delivered in the cold rolled, drawn, ground or machined condition. They may, however, at the option of the manufacturer, be re-heated before or after cold working—in the latter case to a temperature not exceeding 620° C*.

* For this material which is supplied in the cold-rolled or cold-drawn condition, some lack of uniformity in hardness may be expected across the bar, a harder condition existing near the surface; such differences are minimised if the heat treatment mentioned is applied after cold working.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Size (diameter or width across flats), in.			
	¾ or less	Over ¾ to 1¼	Over 1¼ to 2½	Over 2½
Tensile strength, tons/sq. in., min.	35	35	35	32
max.	45	45	45	45
Elongation, per cent, min.	12	12	12	15
Izod impact value, ft. lb., min.	20	15	10	10

*As altered
Feb 1963*

When this steel is required without any special Izod impact values, En 6A should be specified. The material supplied will be identical in composition and mechanical properties with En 6 except for the omission of the Izod impact value.

SEMI-FREE CUTTING CARBON STEEL

(Not recommended for case hardening)

BRIGHT BARS FOR MACHINING

This is a semi-free cutting modification of En 6, for certain restricted applications.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.10	0.30
Silicon	—	0.25
Manganese	1.0	1.30
Sulphur	0.10	0.18
Phosphorus	—	0.060

As altered
Feb 1963

Condition of material on delivery. The bars shall be delivered in the cold drawn condition. They may, however, at the manufacturer's option, be reheated before or after cold working, in the latter case to a temperature not exceeding 620° C.*.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Size (diameter or width across flats), in.				
	½ or less	Over ½ to ¾	Over ¾ to 1 ¼	Over 1 ¼ to 1 ¾	Over 1 ¾ to 2 ½
Tensile strength, tons/sq. in., min.	40	35	35	35	30
max.	50	45	45	45	40
Elongation, per cent, min.	15	15	15	15	12
Izod impact value, ft lb., min.	—	20	15	10	10

* For this material which is supplied in the cold drawn condition, some lack of uniformity in hardness may be expected across the section of the bar, a harder condition existing near the surface; such differences are minimised if the heat treatment mentioned is applied after cold working.

SEMI-FREE CUTTING '15' CARBON STEEL

BRIGHT BARS FOR MACHINING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.12	0.18
Silicon	—	0.25
Manganese	1.00	1.50
Sulphur	0.10	0.18
Phosphorus	—	0.060

Condition of material on delivery. Unless otherwise agreed the bars shall be delivered in the cold drawn condition. They may, however, at the manufacturer's option, be re-heated before or after cold working, in the latter case to a temperature not exceeding 620° C.*.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

HOT ROLLED OR NORMALISED

Limiting ruling section, in.	6
Tensile strength tons/sq. in., min.	28
Elongation, per cent, min.	25

COLD DRAWN

Property	Size (diameter or width across flats), in.		
	¾ or less	Over ¾ to 1 ¼	Over 1 ¼ to 2 ½
Tensile strength, tons/sq. in., min.	35	35	30
max.	45	45	40
Elongation, per cent, min.	15	15	15
Izod impact value, ft lb., min.	20	15	10

* For this material which is supplied in the cold drawn condition, some lack of uniformity in hardness may be expected across the bar, a harder condition existing near the surface; such differences are minimised if the heat treatment mentioned is applied after cold working.

'40' CARBON STEEL
BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 8 Suitable in the hardened and tempered condition for tensile ranges of 40/50 (Q), and 45/55 (R) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, normalised, cold drawn, or hardened and tempered, Q or R, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.05	0.35
Manganese	0.60	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. a. Bars and billets for forging shall be delivered as rolled or forged unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise

As altered Feb 1963 d. Bright bars shall be delivered in accordance with the tables

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7 (other than those from material to be used in the cold drawn condition), and to material supplied in the finally heat treated condition, shall be as follows :—

a. **Material required in the normalised condition :**
Normalise at a temperature of 830/860°C.

b. **Material required in the hardened and tempered condition :**
Harden in oil from a temperature of 830/860°C.
Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

NGC 1. FINALLY NORMALISED OR HARDENED AND TEMPERED
(WITHOUT GRAIN SIZE CONTROL)

As altered Feb. 1963

Property	Condition		
	Normalised	Hardened and tempered	
		Q	R
Limiting ruling section, in.	6	2½	¾
Tensile strength, tons/sq. in., min.	35	40	45
Yield stress, tons/sq. in., min.	18	28	32
Elongation, per cent, min.	20	22	20
Izod impact value, ft. lb., min.	—	10	10
Brinell hardness number	152/207	179/229	201/255

NGC 2 NORMALISED OR HARDENED AND TEMPERED AND FINALLY BRIGHT DRAWN
(WITHOUT GRAIN SIZE CONTROL)

Property	Condition		
	Normalised	Hardened and tempered	
		Q	R
Limiting ruling section, in.	6	2½	¾
Tensile strength, tons/sq. in., min.	35	40	45
Yield stress, tons/sq. in., min.	18	28	32
Elongation, per cent, min.	17	17	17
Brinell hardness number	152/207	179/229	201/255

GC 1 CONTROLLED GRAIN* FINALLY NORMALISED OR HARDENED AND TEMPERED

Property	Condition				
	Normalised		Hardened and tempered		
			Q	R	
Limiting ruling section, in.	4	6	2½	¾	¾
Tensile strength, tons/sq. in., min.	35	35	40	45	45
Yield stress, tons/sq. in., min.	18	18	28	32	32
Elongation, per cent, min.	20	20	22	20	20
Izod impact value, ft. lb., min.	20	15	25	40	25
Brinell hardness number	152/207	152/207	179/229	201/255	201/255

* Controlled grain steel to this specification shall possess a McQuaid-Ehn grain size of 5-8.

En 8, 8A, 8B, 8C, 8D, 8E

As altered
Feb. 1963GC 2. CONTROLLED GRAIN* NORMALISED OR HARDENED
AND TEMPERED AND FINALLY BRIGHT DRAWN

Property	Condition			
	Normalised	Hardened and tempered		
		Q	R	
Limiting ruling section, in.	6	1½	2½	¾
Tensile strength, tons/sq. in., min.	35	40	40	45
Yield stress, tons/sq. in., min.	18	28	28	32
Elongation, per cent, min.	17	17	17	17
Izod impact value, ft. lb., min.	†	25	15	25
Brinell hardness number	152/207	179/229	179/229	201/255

*Controlled grain steel to this specification shall possess a McQuaid-Ehn grain size of 5-8

† An Izod impact value of 10 ft lb minimum is specified where the carbon content does not exceed 0.40 per cent

COLD DRAWN (FOLLOWING HOT ROLLING, i.e. NOT HARDENED
AND TEMPERED)

Property	Size (diameter or width across flats), in.		
	1¼ or less	Over 1¼ to 2½	Over 2½
Tensile strength, tons/sq. in., min.	42	39	37
Elongation, per cent, min.	10	10	10
Brinell hardness number	241 max	229 max.	229 max.

En 8A, 8B, 8C, 8D, 8E For special applications steel of this type may be ordered to specification En 8A, En 8B, En 8C, En 8D, or En 8E, when it will be supplied to a specified composition, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 8A, En 8B, En 8C, En 8D and En 8E, but they may be negotiated between the purchaser and the supplier.

As altered
Feb. 1963

Element	En 8A		En 8B		En 8C		En 8D		En 8E	
	per cent		per cent		per cent		per cent		per cent	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.33	0.38	0.35	0.40	0.38	0.43	0.40	0.45	0.35	0.40
Silicon	0.05	0.35	0.05	0.35	0.05	0.35	0.05	0.35	0.05	0.35
Manganese	0.70	0.70	0.70	0.90	0.70	0.90	0.70	0.90	0.90	1.10
Sulphur	—	0.050	—	0.050	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050	—	0.050	—	0.050

'40' CARBON STEEL (FOR SPECIAL APPLICATIONS)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for a tensile range of 40/50 (Q) tons/sq. in. The purchaser should state on the order the condition, normalised or hardened and tempered, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.05	0.35
Manganese	0.60	1.00
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. a. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining and bright bars shall be delivered in the finally heat treated condition, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

a. Material required in the normalised condition .

Normalise at a temperature of 830/860°C.

b. Material required in the hardened and tempered condition .

Harden in oil from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Condition		
	Normalised		Hardened and tempered Q
Limiting ruling section, in.	6	4	2½
Tensile strength, tons/sq. in., min.	35	35	40
Yield stress, tons/sq. in., min.	18	18	28
Elongation, per cent, min	20	20	22
Izod impact value, ft. lb., min	10	15	25
Brinell hardness number	152/207	152/207	179/229

NOTE When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Condition	
	Normalised	Hardened and tempered Q
Proof stress (0.2 per cent), tons/sq. in., min	17	25

'40' CARBON STEEL—FREE CUTTING

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for tensile ranges of 40/50 (Q), and 45/55 (R) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, normalised, cold drawn, or hardened and tempered, Q or R, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	—	0.25
Manganese	1.0	1.30
Sulphur	0.12	0.20
Phosphorus	—	0.060

As altered
Feb 1963

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7 (other than those from material to be used in the cold drawn condition), and to material supplied in the finally heat treated condition, shall be as follows :—

a. Material required in the normalised condition :

Normalise at a temperature of 830/860°C.

b. Material required in the hardened and tempered condition :

Harden in oil from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	NORMALISED OR HARDENED AND TEMPERED		
	Normalised	Condition	
		Q	R
Limiting ruling section, in	6	2	1/2
Tensile strength, tons/sq in., min.	35	40	45
Yield stress, tons/sq. in., min.	18	28	32
Elongation, per cent, min.	20	22	20
Izod impact value, ft lb, min	—	25	40
Brinell hardness number	152/207	179/229	201/255

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition	
	Q	R
Proof stress (0.2 per cent), tons/sq in, min	25	30

COLD DRAWN

Maximum size (diameter or width across flats), in.	1 1/2
Tensile strength, tons/sq. in., min.	38
Elongation, per cent, min.	12
Brinell hardness number, max.	229

En 8AM, 8BM, 8CM, 8DM For special applications steel of this type may be ordered to specifications En 8AM, En 8BM, En 8CM or En 8DM, when it will be supplied to a specified composition the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 8AM, En 8BM, En 8CM and En 8DM but they may be negotiated between the purchaser and the supplier.

As altered Feb 1963

Element	En 8AM		En 8BM		En 8CM		En 8DM	
	per cent		per cent		per cent		per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.33	0.38	0.35	0.40	0.38	0.43	0.40	0.45
Silicon	—	0.25	—	0.25	—	0.25	—	0.25
Manganese	0.90	1.30	0.90	1.30	0.90	1.30	0.90	1.30
Sulphur	0.12	0.20	0.12	0.20	0.12	0.20	0.12	0.20
Phosphorus	—	0.060	—	0.060	—	0.060	—	0.060

'55' CARBON STEEL

En 9K is intended for special applications only

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for tensile ranges of 45/55 (R), 50/60 (S) and 55/65 (T) tons/sq. in. The purchaser should state on the order the condition, normalised, cold drawn, or hardened and tempered, R, S or T, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	En 9		En 9K	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.50	0.60	0.50	0.60
Silicon	0.05	0.35	0.05	0.35
Manganese	0.50	0.80	0.50	0.80
Sulphur	—	0.060	—	0.050
Phosphorus	—	0.060	—	0.050

Condition of material on delivery. a. Bars and billets for forgings shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7 (other than those from material to be used in the cold drawn condition), and to material supplied in the finally heat treated condition, shall be as follows :—

a. Material required in the normalised condition :

Normalise at a temperature of 810/840°C.

b. Material required in the hardened and tempered condition :

Harden in oil from a temperature of 810/840°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

NORMALISED OR HARDENED AND TEMPERED

Property	Condition			
	Normalised	Hardened and tempered		
		R	S	T
Limiting ruling section, in.	4	2	1½	1½
Tensile strength, tons/sq. in., min.	45	45	50	55
Yield stress, tons/sq. in., min.	23	30	33	36
Elongation, per cent, min.	18	18	18	15
Brinell hardness number	201/255	201/255	223/277	248/302

NOTE. Steel to En 9K shall comply with the following requirements when proof stress tests are specifically requested in the enquiry and order :—

Property	Hardened and tempered condition		
	R	S	T
Proof stress (0.2 per cent), tons/sq in., min	28	31	34

COLD DRAWN

Maximum size (diameter or width across flats), in.	2
Tensile strength, tons/sq. in., min.	50
max.	65
Elongation, per cent, min.	12
Brinell hardness number	223/302

'55' CARBON, ¾ PER CENT NICKEL STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

This steel is used to a limited extent for special applications and will be supplied to a specified composition, the limits of which are as follows:

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	0.50	0.60
Silicon	0.05	0.35
Manganese	0.50	0.80
Nickel	0.50	0.80
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forgings shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to this steel shall be agreed between the purchaser and manufacturer.

' 60 ' CARBON-CHROMIUM STEEL

**BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS**

Suitable for tensile ranges of 55/65 (T) and 65/75 (V) tons/sq. in. The purchaser should state on the order, the condition, T or V, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.50	0.70
Silicon	0.10	0.35
Manganese	0.50	0.80
Chromium	0.50	0.80
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 800/850°C.

Temper at a suitable temperature between 500°C and 700°C.

Mechanical properties. The mechanical properties obtained from test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition	
	T	V
Limiting ruling section, in.	2½	2½
Tensile strength, tons/sq. in., min.	55	65
Yield stress, tons/sq. in., min.	40	48
Elongation, per cent, min.	15	12
Izod impact value, ft. lb., min.	25	12
Brinell hardness number	248/302	293/341

1 PER CENT NICKEL STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for a tensile range of 40/50 (Q) tons/sq. in. The purchaser should state on the order the condition, normalised, or hardened and tempered, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.30	0.45
Silicon	0.1	0.35
Manganese	—	1.50
Nickel	0.60	1.00
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

a. Material required in the normalised condition :
Normalise at a temperature of 830/860°C.

b. Material required in the hardened and tempered condition :
Harden in oil from a temperature of 830/860°C.
Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Condition			
	Normalised		Hardened and tempered, Q	
Limiting ruling section, in.	6	4	6	4
Tensile strength, tons/sq in., min.	35	35	40	40
Yield stress, tons/sq in., min.	20	20	30	30
Elongation, per cent, min.	20	20	22	22
Izod impact value, ft. lb., min.	15	20	25	35
Brinell hardness number	152/207	152/207	17/229	179/229

NOTE When proof stress tests are specifically requested in the enquiry and order the value for En 12Q shall be as follows :—

Proof stress (0.2 per cent) tons/sq in., min 27

For special applications steel of this type may be ordered to specifications En 12A, En 12A, En 12B or En 12C, when it will be supplied to specified composition, the limits of 12B, C12 which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 12A, En 12B and En 12C but they may be negotiated between the purchaser and the supplier. *As altered Feb 1963*

Element	En 12A		En 12B		En 12C	
	per cent		per cent		per cent	
	min.	max.	min.	max.	min.	max.
Carbon	0.30	0.35	0.35	0.40	0.40	0.45
Silicon	0.10	0.35	0.10	0.35	0.10	0.35
Manganese	0.70	0.90	0.70	0.90	0.70	0.90
Nickel	0.60	1.00	0.60	1.00	0.60	1.00
Sulphur	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050

MANGANESE-NICKEL-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 40/50 (Q) tons/sq in.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.15	0.25
Silicon	0.10	0.35
Manganese	1.40	1.80
Nickel	0.40	0.70
Molybdenum	0.15	0.35
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows —

Harden in oil from a temperature of 850/890°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows —

Condition	Hardened and tempered, Q
Limiting ruling section, in.	6
Tensile strength, tons/sq. in., min.	40
Yield stress, tons per sq. in., min.	30
Elongation, per cent, min.	22
Izod impact value, ft. lb., min.	40
Brinell hardness number	179/229

NOTE When proof stress tests are specifically requested in the enquiry and order, the value for En 13Q shall be as follows :—

Proof stress (0.2 per cent) tons/sq in, min 27

CARBON-MANGANESE STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for tensile ranges of 40/50 (Q) and 45/55 (R) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition normalised, cold drawn or hardened and tempered, Q or R, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min	max.
Carbon	0.15	0.25
Silicon	0.10	0.35
Manganese	1.30	1.70
Nickel	—	0.40
Chromium	—	0.25
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, other than those from material to be used in cold drawn conditions, and to material supplied in the finally heat treated condition, shall be as follows —

a. Material required in the normalised condition :

Normalise at a temperature of 860/900°C.

b. Material required in the hardened and tempered condition :

Harden in oil or water from a temperature of 860/900°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	NORMALISED OR HARDENED AND TEMPERED		
	Normalised	Condition	
		Q	R
Limiting ruling section, in.	6	4	1 1/2
Tensile strength, tons/sq. in., min.	35	40	45
Yield stress, tons/sq. in., min.	21	28	32
Elongation, per cent., min.	20	20	20
Izod impact value, ft. lb., min.	15*	30	25
Brinell hardness number	152/207	179/229	201/255

As altered
Feb 1963

* 30 for controlled grain steel

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition	
	Q	R
Proof stress (0.2 per cent), tons/sq. in., min.	26	30

COLD DRAWN

Maximum size (diameter or width across flats), in 2

Tensile strength, tons/sq. in., min. 45

Elongation per cent., min. 15

Izod impact value, ft. lb., min. 15

NOTE. When this steel is required in the form of plate, sheet and strip it should be ordered to B S 1449, 'Steel plate, sheet and strip'.

CARBON-MANGANESE STEEL (FOR SPECIAL APPLICATIONS)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

The purchaser should state on the order the condition, hot rolled or normalised, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max
Carbon	—	0.23
Silicon	0.05	0.35
Manganese	1.20	*
Copper (optional)	—	0.60
Sulphur	—	0.060
Phosphorus	—	0.060

* Manganese plus residual nickel, chromium and molybdenum shall not exceed 2.0 per cent

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the normalised condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the normalised condition, unless the order states otherwise.

Heat treatment. The heat treatment to be given, where appropriate, to the test bars selected as stated in Clause 7 and to material supplied in the normalised condition shall be as follows :—

Normalise at a temperature of 860/900°C.

Mechanical properties. The mechanical properties obtained from test pieces selected and prepared as stated in the appropriate general clause shall be as follows :—

HOT ROLLED OR NORMALISED

Limiting ruling section, in.	1½	2½
Tensile strength, tons/sq. in., min.	35	33
	max.	41
Elongation, per cent, min.	18	18

NOTE When proof stress tests are specifically requested in the enquiry and order the values shall be as follows :—

Tensile strength, tons/sq. in.	35/41	33/39
Proof stress (0.2 per cent), tons/sq. in., min	21	19

CARBON-MANGANESE STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for tensile ranges of 40/50 (Q) and 45/55 (R) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, normalised, cold drawn or hardened and tempered, Q or R for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.20	0.30
Silicon	0.10	0.35
Manganese	1.30	1.70
Nickel	—	0.40
Sulphur	—	0.060
Phosphorus	—	0.060

- Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.
- b.* Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.
- c.* Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.
- d.* Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7 (other than those from steel to be used in the cold drawn condition), and to material supplied in the finally heat treated condition, shall be as follows :—

- a. Material required in the normalised condition :*
Normalise at a temperature of 840/880°C.
- b. Material required in the hardened and tempered condition :*
Harden in oil or water from a temperature of 840/880°C.
Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	NORMALISED OR HARDENED AND TEMPERED		
	Normalised	Condition	
		Q	R
Limiting ruling section, in.	—	4	2½
Tensile strength, tons/sq. in., min.	58	40	45
Yield stress, tons/sq. in., min.	23	28	32
Elongation, per cent, min.	20	20	20
Izod impact value, ft. lb., min.	15*	35	30
Brinell hardness number	170/223	179/229	201/255

As altered
Feb 1963

* 30 for controlled grain steel.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition	
	Q	R
Proof stress (0.2 per cent), tons/sq. in., min	26	30

COLD DRAWN

Maximum size (diameter or width across flats), in.	2
Tensile strength, tons/sq. in., min.	45
Elongation, per cent, min.	15
Izod impact value, ft. lb. min.	15

CARBON-MANGANESE STEEL (HIGHER TENSILE)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 40/50 (Q), 45/55 (R), and 50/60 (S) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, Q, R or S, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.30	0.40
Silicon	0.10	0.35
Manganese	1.30	1.70
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 840/870°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition			
	Q	R	S	
Limiting ruling section, in.	6	4	2½	¾
Tensile strength, tons/sq. in., min.	40	40	45	50
Yield stress, tons/sq. in., min.	28	28	34	38
Elongation, per cent, min.	22	22	20	20
Izod impact value, ft. lb., min	25	35	30	30
Brinell hardness number	179/229	179/229	201/255	223/277

NOTE. When proof stress tests are specifically requested in the enquiry and order the value shall be as follows :—

Property	Hardened and tempered condition		
	Q	R	S
Proof stress (0.2 per cent), tons/sq. in., min	26	32	36

CARBON-MANGANESE STEEL (HIGHER TENSILE)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 40/50 (Q), 45/55 (R), and 50/60 (S) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, Q, R or S, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.30	0.40
Silicon	0.05	0.35
Manganese	1.30	1.70
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forging and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :

Harden in oil from a temperature of 840/870°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition		
	Q	R	S
Limiting ruling section, in.	4	2½	¾
Tensile strength, tons/sq. in., min.	40	45	50
Yield stress, tons/sq. in., min.	28	34	38
Elongation, per cent, min.	22	20	20
Izod impact value, ft. lb., min.	25	25	25
Brinell hardness number	179/229	201/255	223/277

CARBON-MANGANESE STEEL—FREE CUTTING

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 45/55 (R) tons/sq. in.

Chemical composition. The steel shall contain:

Element	Per cent	
	min	max.
Carbon	0.30	0.40
Silicon	—	0.25
Manganese	1.30	1.70
Sulphur	0.12	0.20
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forging and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows:—

Harden in oil from a temperature of 840/870°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Condition	Hardened and tempered, R
Limiting ruling section, in.	2½
Tensile strength, tons/sq. in., min.	45
Yield stress, tons/sq. in., min.	34
Elongation, per cent, min.	20
Izod impact value, ft. lb., min.	25
Brinell hardness number	201/255

CARBON-MANGANESE STEEL (HIGHER TENSILE)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 40/50 (Q), 45/55 (R), 50/60 (S), and 55/65 (T) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, Q, R, S, or T, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.40
Silicon	0.05	0.35
Manganese	1.10	1.30
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forgings shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 840/870°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition			
	Q	R	S	T
Limiting ruling section	4	2½	¾	¾
Tensile strength, tons/sq. in., min.	40	45	50	55
Yield stress, tons/sq. in., min.	26	32	36	42
Elongation, per cent, min.	20	20	20	18
Izod impact value, ft. lb., min.	25	25	25	25
Brinell hardness number	179/229	201/255	223/277	248/302

MANGANESE-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 16, Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), 60/70 (U) and 65/75 (V) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T, U or V, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min	max.
Carbon	0.30	0.40*
Silicon	0.10	0.35
Manganese	1.30	1.80
Molybdenum	0.20	0.35
Sulphur	—	0.050
Phosphorus	—	0.050

* For small ruling sections, or when the steel is to be hardened in water, the carbon content by agreement between the purchaser and the manufacturer shall be 0.25/0.35 per cent and the steel will be designated as En 16D.

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil† from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 660°C.

Material supplied in the finally heat treated condition may be hardened in water if suitable precautions are taken, but it is recommended that in such cases the carbon content should not exceed 0.35 per cent.

† When parts to En 16D are to be water quenched, this shall be stated on the order and the test bars shall be similarly heat treated.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Limiting ruling section	6	4	2½	1½	¾
Tensile strength, tons/sq. in., min	45	50	55	60	65
Yield stress, tons/sq. in., min.	34	38	44	48	52
Elongation, per cent. min.	22	20	18	17	16
Izod impact value, ft. lb., min	40	40	40	35	35
Brinell hardness number	201/255	223/277	248/302	269/321	293/341

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Proof stress (0.2 per cent) tons/sq. in., min.	32	36	41	46	50

For special applications steel of this type may be ordered to specification En 16A, En 16A, En 16B or En 16C, when it will be supplied to a specified composition only, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 16A, En 16B and En 16C.

Element	En 16A		En 16B		En 16C	
	Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.
Carbon	0.25	0.30	0.30	0.35	0.35	0.40
Silicon	0.10	0.35	0.10	0.35	0.10	0.35
Manganese	1.30	1.80	1.30	1.80	1.30	1.80
Molybdenum	0.20	0.35	0.20	0.35	0.20	0.35
Sulphur	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050

MANGANESE-MOLYBDENUM STEEL—FREE CUTTING

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	0.30	0.40
Silicon	—	0.25
Manganese	1.30	1.80
Molybdenum	0.20	0.35
Sulphur	0.12	0.20
Phosphorus	—	0.02

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows:—

Harden in oil from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. If required, mechanical properties shall be agreed between the purchaser and the manufacturer.

MANGANESE-MOLYBDENUM STEEL (HIGHER MOLYBDENUM)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), 60/70 (U) and 65/75 (V) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T, U or V, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.30	0.40
Silicon	0.10	0.35
Manganese	1.30	1.80
Molybdenum	0.35	0.55
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 660°C.

Material supplied in the finally heat treated condition may be hardened in water if suitable precautions are taken, but it is recommended that in such cases the carbon content should not exceed 0.35 per cent.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Limiting ruling section, in	6	6	4	2½	1½
Tensile strength, tons/sq. in., min.	45	50	55	60	65
Yield stress, tons/sq. in., min.	34	38	44	48	52
Elongation, per cent, min.	22	20	18	17	16
Izod impact value, ft. lb., min.	40	40	40	35	35
Brinell hardness number	201 255	223 277	248 302	269 321	293 341

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows:—

Property	Hardened and tempered condition				
	R	S	T	U	V
Proof stress (0.2 per cent) tons/sq in., min.	32	36	41	46	50

1 PER CENT CHROMIUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 18 Suitable for tensile ranges of 45/55 (R), 50/60 (S) and 55/65 (T) tons/sq. in according to the ruling section of the part. The purchaser should state on the order the condition R, S, or T for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.60	0.95
Chromium	0.85	1.15
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or water from a temperature of 850/880°C.

Temper at a suitable temperature between 550°C. and 700°C.

Steels in the upper part of the composition range should not be water hardened unless special precautions are taken.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition		
	R	S	T
Limiting ruling section, in.	4	2½	1½
Tensile strength, tons/sq. in., min.	45	50	55
Yield stress, tons/sq. in., min.	34	38	44
Elongation, per cent, min.	22	20	18
Izod impact value, ft. lb., min.	40	40	40
Brlnell hardness number	201/255	223/277	248/302

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition		
	R	S	T
Proof stress (0.2 per cent), tons/sq. in., min.	32	36	41

For special applications steel of this type may be ordered to specification En 18A, En 18A, En 18B, En 18C or En 18D, when it will be supplied to a specified composition only, 18B, 18C, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 18A, En 18B, En 18C and En 18D.

Element	En 18A		En 18B		En 18C		En 18D	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.27	0.32	0.30	0.35	0.35	0.38	0.38	0.43
Silicon	0.10	0.35	0.10	0.35	0.10	0.35	0.10	0.35
Manganese	0.65	0.80	0.65	0.80	0.65	0.80	0.65	0.80
Chromium	0.85	1.15	0.85	1.15	0.85	1.15	0.85	1.15
Sulphur	—	0.050	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050	—	0.050

1 PER CENT CHROMIUM-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), 60/70 (U), 65/75 (V), 70/80 (W) and 80/90 (Y) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T, U, V, W or Y, for which the steel is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.50	0.80
Chromium	0.90	1.50
Molybdenum	0.20	0.40
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 850/880°C.

Temper at a suitable temperature between 550°C. and 720°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition						
	R	S	T	U	V	W	Y
Limiting ruling section, in.	6	4	2½	2½	1½	1½	1
Tensile strength, tons/sq. in., min.	45	50	55	60	65	70	80
Yield stress, tons/sq. in., min.	34	38	44	48	52	58	68
Elongation, per cent, min.	22	20	18	17	16	15	10
Izod impact value, ft. lb., min.	40	40	40	35	35	30	10
Brinell hardness number	201/255	223/277	248/302	269/321	293/341	311/375	363/415

NOTE 1. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition						
	R	S	T	U	V	W	Y
Proof stress (0.2 per cent) tons/sq. in. min.	32	36	41	46	50	55	61

NOTE 2. In cases where the higher tensile ranges are not required or the ruling section is smaller, the steel may be ordered to specification En 19A

1 PER CENT CHROMIUM-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 19A Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), 60/70 (U) and 65/75 (V) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T, U or V, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.50	0.80
Chromium	0.90	1.20
Molybdenum	0.20	0.35
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. a. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 850/880°C.

Temper at a suitable temperature between 550°C and 720°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Limiting ruling section, in.	6	4	2½	1¾	¾
Tensile strength tons/sq. in., min.	45	50	55	60	65
Yield stress, tons/sq. in., min.	34	38	44	48	52
Elongation, per cent, min.	22	20	18	17	16
Izod impact value, ft. lb., min.	40	40	40	35	35
Brinell hardness number	201/255	223/277	248/302	269/321	293/341

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Proof stress (0.2 per cent) tons/sq. in., min.	32	36	41	46	50

For special applications steel of this type may be ordered to specification En 19B or En 19C, when it will be supplied to a specified composition only, limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 19B and En 19C.

En 19B,
19C

Element	Specification			
	En 19B		En 19C	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.35	0.40	0.40	0.45
Silicon	0.10	0.35	0.10	0.35
Manganese	0.50	0.80	0.50	0.80
Chromium	0.90	1.20	0.90	1.20
Molybdenum	0.20	0.35	0.20	0.35
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

**1 PER CENT CHROMIUM-MOLYBDENUM STEEL
(HIGHER MOLYBDENUM)
FOR HIGH TEMPERATURE BOLTS**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 55/65 (T), 60/65 (U), and 65/75 (V) tons/sq.in. according to the ruling section of the part. The purchaser should state on the order the condition, T, U or V, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	En 20A		En 20B	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.20	0.30	0.35	0.45
Silicon	0.10	0.35	0.10	0.35
Manganese	0.40	0.70	0.40	0.70
Chromium	0.50	1.00	1.00	1.50
Molybdenum	0.50	0.80	0.50	0.90
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or water from a temperature of 850/900°C.
Temper at a suitable temperature between 550°C. and 720°C.

The water hardening treatment is more suitable for En 20A and the oil hardening treatment is more suitable for En 20B.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition		
	T	U	V
Limiting ruling section, in.	2½	2½	1½
Tensile strength, tons/sq. in., min.	55	60	65
Yield stress, tons/sq. in., min.	44	48	52
Elongation, per cent min.	18	17	16
Izod impact value, ft. lb., min.	40	35	35
Brinell hardness number	248/302	269/321	293/341

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition		
	T	U	V
Proof stress (0.2 per cent) tons/sq. in., min.	41	46	50

3 PER CENT NICKEL STEEL

BAR3 AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 21 Suitable for tensile ranges of 45/55 (R) and 50/60 (S) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, R or S, for which the steel is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.25	0.35
Silicon	0.10	0.35
Manganese	0.35	0.75
Nickel	2.75	3.25
Chromium	—	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or water from a temperature of 830/860°C
Temper at a suitable temperature between 500°C. and 650°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition	
	R	S
Limiting ruling section, in.	4	2½
Tensile strength, tons/sq. in., min.	45	50
Yield stress, tons/sq. in., min.	32	38
Elongation, per cent, min.	22	20
Izod impact, ft. lb. min.	40	40
Brinell hardness number	201/255	223/277

NOTE When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition	
	R	S
Proof stress (0.2 per cent) tons/sq. in., min.	33	36

Steel of this type may also be required in the form of plate and sheet En 21A (see B.S. 1449, 'Steel plate, sheet and strip'), the chemical composition of this steel is as follows :—

Element	Per cent	
	min.	max.
Carbon	0.20	0.30
Silicon	0.10	0.35
Manganese	—	0.60
Nickel	2.50	3.50
Sulphur	—	0.050
Phosphorus	—	0.050

3½ PER CENT NICKEL STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 50/60 (S) and 55/65 (T) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, S or T, for which the steel is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.50	0.80
Nickel	3.25	3.75
Chromium	—	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C and 650°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition	
	S	T
Limiting ruling section, in.	4	2½
Tensile strength, tons/sq. in., min	50	55
Yield stress, tons/sq. in., min.	38	44
Elongation, per cent, min.	20	18
Izod impact value, ft. lb., min.	40	40
Brinell hardness number	223/277	248/302

NOTE When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition	
	S	T
Proof stress (0.2 per cent) tons/sq. in., min.	36	41

3 PER CENT NICKEL-CHROMIUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 50/60 (S), 55/65 (T), 60/70 (U) or 65/75 (V) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, S, T, U or V, for which the material is ultimately required.

Chemical composition. The steel shall contain .

Element	Per cent	
	min.	max.
Carbon	0.25	0.35
Silicon	0.10	0.35
Manganese	0.45	0.70
Nickel	2.75	3.50
Chromium	0.50	1.00
Molybdenum (optional*)	—	0.65
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C.

Temper at a suitable temperature between 550°C. and 660°C.

NOTE. If an adequate content of molybdenum is not present it is preferable to cool in oil or water after tempering.

* See Clause 4 *c.*

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the general clauses shall be as follows :—

Property	Hardened and tempered condition			
	S	T	U	V
Limiting ruling section	6	6	6	2½
Tensile strength, tons/sq. in., min	50	55	60	65
Yield stress, tons/sq. in., min	38	44	48	52
Elongation, per cent, min	20	18	17	16
Izod impact value, ft. lb., min	40	40	35	35
Brinell hardness number	223/277	246/302	269/321	293/341

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 269.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition			
	S	T	U	V
Proof stress (0.2 per cent) tons/sq. in., min	36	41	46	50

1½ PER CENT NICKEL-CHROMIUM-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 50/60 (S), 55/65 (T), 60/70 (U), 65/75 (V), 70/80 (W), 75/85 (X), 80/90 (Y), and 100 (Z) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, S, T, U, V, W, X, Y or Z, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.45	0.70
Nickel	1.30	1.80
Chromium	0.90	1.40
Molybdenum	0.20	0.35
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C.

Temper at a suitable temperature not exceeding 650°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition							
	S	T	U	V	W	X	Y	Z
Limiting ruling section, in	6	6	4	2½	1½	1½	1½	1½
Tensile strength, tons sq. in., min	50	55	60	65	70	75	80	100
Yield stress, tons/sq. in., min	38	44	48	52	58	63	68	85
Elongation, per cent, min	20	18	17	16	15	14	14	8
Izod impact value, ft lb., min	40	40	35	35	30	25	22	8
Brinell hardness numbers	223/277	248/302	269/321	293/341	311/375	341/388	363/415	444 min

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 277.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition							
	S	T	U	V	W	X	Y	Z
Proof stress (0.2 per cent), tons/sq. in., min	36	41	46	50	55	59	64	80

**2½ PFR CENT NICKEL-CHROMIUM-MOLYBDENUM STEEL
(MEDIUM CARBON)**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 55/65 (T), 60/70 (U), 65/75 (V), 70/80 (W), 75/85 (X), 80/90 (Y), and 100 (Z) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, T, U, V, W, X, Y or Z, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.27	0.35
Silicon	0.10	0.35
Manganese	0.50	0.70
Nickel	2.30	2.80
Chromium	0.50	0.80
Molybdenum	0.40	0.70
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C.

Temper at a suitable temperature not exceeding 660°C

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition							
	T	U	V		W	X	Y	Z
Limiting ruling section, in.	6	6	6	4	4	2½	2½	2½
Tensile strength, tons/sq. in., min.	55	60	65	65	70	75	80	100
Yield stress, tons/sq. in., min.	44	48	52	52	58	63	68	85
Elongation, per cent, min.	18	17	14	16	15	14	14	10
Izod impact value, ft lb, min.	40	35	35	35	30	25	25	10
Brinell hardness number	248/ 302	269/ 321	293/ 341	293/ 341	311/ 375	341/ 388	363/ 415	444 min

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 277.

NOTE When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition						
	T	U	V	W	X	Y	Z
Proof stress (0.2 per cent), tons/sq. in., min.	41	46	50	55	59	64	80

2½ PER CENT NICKEL-CHROMIUM-MOLYBDENUM STEEL
(HIGH CARBON)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 60/70 (U), 65/75 (V), 70/80 (W), 75/85 (X), 80/90 (Y) and 100 (Z) tons/sq. in according to the ruling section of the part. The purchaser should state on the order the condition, U, V, W, X, Y or Z, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min	max.
Carbon	0.36	0.44
Silicon	0.10	0.35
Manganese	0.50	0.70
Nickel	2.30	2.80
Chromium	0.50	0.80
Molybdenum	0.40	0.70
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the opt. of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C.
Temper at a suitable temperature not exceeding 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardener' and tempered condition										
	U		V		W		X		Y		Z
Limiting ruling section in.	6	6	4	6	4	6	4	6	4	4	
Tensile strength, tons/sq. in, min	60	65	65	70	70	75	75	80	80	100	
Yield stress, tons/sq. in., min	48	52	52	58	58	63	63	68	68	85	
Elongation, per cent, min	17	14	16	13	15	12	14	12	14	10	
Izod impact value, ft. lb., min.	35	35	35	30	30	25	25	25	25	10	
Brinell hardness number	269/321	293/341	293/341	311/375	311/375	341/388	341/388	363/415	363/415	444	min

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 277.

NOTE When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition					
	U	V	W	X	Y	Z
Proof stress (0.2 per cent), tons/sq. in, min	46	50	55	59	64	80

3 PER CENT NICKEL-CHROMIUM-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 55/65 (T), 60/70 (U), 65/75 (V), and 70/80 (W) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, T, U, V or W, for which the material is ultimately required.

Chemical composition. The steel shall contain .

Element	Per cent	
	min	max.
Carbon	0.25	0.35
Silicon	0.10	0.35
Manganese	—	0.70
Nickel	3.00	3.75
Chromium	0.50	1.30
Molybdenum	0.20	0.65
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C.

Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	T	U	V	W	
Limiting ruling section, in.	6	6	6	4	4
Tensile strength, tons/sq. in., min	55	60	65	65	70
Yield stress, tons/sq. in., min	44	48	52	52	58
Elongation, per cent, min	18	17	14	16	15
Izod impact value, ft. lb., min.	40	35	35	35	30
Brinell hardness number	248/302	269/321	293/341	293/341	311/375

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 277.

NOTE When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition			
	T	U	V	W
Proof stress (0.2 per cent), tons/sq. in., min.	41	46	50	55

3½ PER CENT NICKEL-CHROMIUM-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 60/70 (U), 65/75 (V), 70/80 (W) and 80/90 (Y) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, U, V, W or Y, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.25	0.40
Silicon	0.10	0.35
Manganese	—	0.70
Nickel	3.00	4.50
Chromium	0.75	1.50
Molybdenum	0.20	0.65
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise, except when required for condition Y, when the bars shall be supplied softened.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C.
Temper at a suitable temperature between 500°C. and 660°C

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	U	V	W	Y	
Limiting ruling section, in.	6	6	4	4	2½
Tensile strength, tons/sq. in., min.	60	65	65	70	80
Yield stress, tons/sq. in., min.	48	52	52	58	68
Elongation, per cent, min.	17	14	16	15	14
Izod impact value, ft. lb., min.	35	35	35	30	25
Brinell hardness number	269/321	293/341	293/341	311/375	363/415

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 277.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition			
	U	V	W	Y
Proof stress (0.2 per cent), tons/sq. in., min.	46	50	55	64

3 PER CENT CHROMIUM-MOLYBDENUM STEEL
(For particulars of this steel as a nitriding steel see En 40A and En 40B)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), 60/70 (U), 65/75 (V), 70/80 (W) and 100 (Z) tons/sq. in., according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T, U, V, W or Z, for which the material is ultimately required. The selection of En 29A or En 29B will be governed by the tensile range required.

Chemical composition. The steel shall contain :

Element	En 29A Per cent		En 29B Per cent.	
	min.	max.	min.	max.
Carbon	0.15	0.25	0.25	0.35
Silicon	0.10	0.35	0.10	0.35
Manganese	—	0.65	—	0.65
Nickel	—	0.40	—	0.40
Chromium	2.50	3.50	2.50	3.50
Molybdenum	0.30	0.70	0.30	0.70
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. a. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise, except when required for condition Z, when the bars shall be supplied softened.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or still air from a temperature of 880,910°C.
Temper at a suitable temperature not exceeding 750°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition						
	R	S	T	U	V	W	Z
Limiting ruling section, in.	6	6	6	6	4	4	2½
Tensile strength, tons/sq. in., min	45	50	55	60	65	70	100
Yield stress, tons/sq. in., min	34	38	44	48	52	58	85
Elongation, per cent, min	22	20	18	17	16	15	10
Izod impact value, ft lb., min.	40	40	40	35	35	30	10
Brinell hardness number	201/ 255	223/ 277	248/ 302	269/ 321	293/ 341	311/ 375	444/ min

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 269.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition						
	R	S	T	U	V	W	Z
Proof stress (0.2 per cent), tons/sq. in., min	32	36	41	46	50	55	80

**4¼ PER CENT NICKEL-CHROMIUM STEEL
(WITH OR WITHOUT MOLYBDENUM)**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Suitable for a tensile strength of 100 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	En 30A		En 30B	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.26	0.34	0.26	0.34
Silicon	0.10	0.35	0.10	0.35
Manganese	0.40	0.60	0.40	0.60
Nickel	3.90	4.30	3.90	4.30
Chromium	1.10	1.40	1.10	1.40
Molybdenum	—	—	0.20	0.40
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the softened condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test pieces, selected and prepared as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Harden in air (or in oil for larger masses*) from a temperature of 810/830°C.

Temper, if desired, at a suitable temperature not exceeding 250°C.

* For parts with ruling sections up to 2½ in. the properties stated can be obtained by air hardening and this treatment is preferable, but for larger sizes up to a ruling section of 6 in. oil hardening is necessary.

Mechanical properties. The mechanical properties obtained from samples selected and prepared as stated in the appropriate general clauses and air hardened and tempered in test piece size shall be as follows :—

Property	En 30A	En 30B
Tensile strength, tons/sq. in., min.	100	100
Yield stress, tons/sq. in., min.	85	85
Elongation, per cent, min.	10	10
Izod impact value, ft. lb., min.	10	15
Brinell hardness number	444	444

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 285.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the value shall be as follows :—

Proof stress (0.2 per cent), tons/sq. in., min. 80

1 PER CENT CARBON-CHROMIUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING

Suitable for parts of maximum hardness

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.90	1.20
Silicon	0.10	0.35
Manganese	0.30	0.75
Chromium	1.00	1.60
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the softened condition, unless the order states otherwise

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise

Heat treatment. The heat treatment recommended for this steel is as follows :—

Harden in oil or water from a temperature of 800/840°C

Hardened parts may be lightly tempered at a temperature of 130/180°C., but tempering at temperatures in excess of 200°C. may lead to an undue loss of hardness.

Mechanical properties. When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 229.

CARBON CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Recommended for limiting ruling sections of $\frac{1}{8}$ in. and below.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.15
Silicon	0.05	0.35
Manganese	0.40	0.70
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered in the cold worked or bright machined condition, unless the order states otherwise.

Heat treatment.*† The heat treatment to be given to the test bars selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C., cool in air, oil, or water

Harden in water from a temperature of 760/780°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min	32
Elongation, per cent, min.	20
Izod impact value, ft. lb., min.	40

* See Appendix A for single quench treatment

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

CARBON CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Recommended for limiting ruling sections over ½ in.

Chemical composition. The steel shall contain :

Element	En 32B		En 32C	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.10	0.18	0.10	0.18
Silicon	0.05	0.35	0.05	0.35
Manganese	0.60	1.00	0.60	1.00
Sulphur	—	0.070†	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered in the cold worked or bright machined condition, unless the order states otherwise.

Heat treatment.* ‡ The heat treatment to be given to the 1 ¼ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C., cool in air, oil or water.

Harden in water from a temperature of 760/780°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	32
Elongation, per cent, min.	20
Izod impact value, ft. lb., min.	40

† The higher sulphur content is to assist machinability.

* See Appendix A for 'single quench' treatment.

‡ By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

CARBON CASE-HARDENING STEEL
(SEMI-FREE CUTTING)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Chemical composition. The steel shall contain .

Element	Per cent	
	min.	max.
	Carbon	0.10
Silicon	0.05	0.35
Manganese†	0.90	1.20
Sulphur†	0.10	0.15
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered in the cold worked, or bright machined condition, unless the order states otherwise.

Heat treatment.* ‡ The heat treatment to be given to the 1 ¼ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C., cool in air, oil or water.

Harden in water from a temperature of 760/780°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min	32
Elongation, per cent, min.	20
Izod impact value, ft. lb., min	40

† The high sulphur and manganese contents are for increased machinability.

* See Appendix A for 'single quench' treatment.

‡ By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

3 PER CENT NICKEL CASE-HARDENING STEEL.

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP-FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 45 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.10	0.15
Silicon	0.10	0.35
Manganese	0.30	0.60
Nickel	2.75	3.50
Chromium	—	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in water from a temperature of 760/780°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

In practice it may be desirable not to quench parts in water, but to harden them in oil from the temperature stated.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows —

Tensile strength, tons/sq. in., min.	45
Elongation, per cent, min.	18
Izod impact value, ft. lb., min.	40

**2 PER CENT NICKEL-MOLYBDENUM CASE-HARDENING
STEEL (LOWER CARBON)**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 45 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.14	0.20
Silicon	0.10	0.35
Manganese	0.30	0.60
Nickel	1.50	2.00
Molybdenum	0.20	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1 3/8 in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 760/780°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	45
Elongation, per cent, min.	18
Izod impact value, ft. lb., min.	40

En 35, 35A and 35B

2 PER CENT NICKEL-MOLYBDENUM CASE-HARDENING STEEL (HIGHER CARBON)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 35 Suitable for a tensile strength of 55 tons/sq. in. min

Chemical composition. The steel shall contain *

Element	Per cent	
	min.	max.
Carbon	0.20	0.28
Silicon	0.10	0.35
Manganese	0.30	0.60
Nickel	1.50	2.00
Molybdenum	0.20	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. a. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 760/780°C.

* See Appendix for 'single quench' treatment

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period

En 35, 35A and 35B

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	55
Elongation, per cent., min.	15
Izod impact value, ft. lb., min.	22

For special applications steel of this type may be ordered to specification En 35A, En 35A or En 35B, when it will be supplied to a specified composition 35B only, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 35A and En 35B.

Element	En 35A		En 35B	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.20	0.25	0.23	0.28
Silicon	0.10	0.35	0.10	0.35
Manganese	0.30	0.60	0.30	0.60
Nickel	1.50	2.00	1.50	2.00
Molybdenum	0.20	0.30	0.20	0.30
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

En 36A, 36B, 36C

3 PER CENT NICKEL-CHROMIUM AND NICKEL-CHROMIUM-MOLYBDENUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile strengths of 55 (En 36A) and 65 (En 36B and En 36C) tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	En 36A		En 36B		En 36C	
	Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.
Carbon	—	0.15	0.12	0.18	0.12	0.18
Silicon	0.10	0.35	0.10	0.35	0.10	0.35
Manganese	0.30	0.60	0.30	0.60	0.30	0.60
Nickel	3.00	3.75	3.00	3.75	3.00	3.75
Chromium	0.60	1.10	0.60	1.10	0.60	1.10
Molybdenum	—	—	—	—	0.10	0.25
Sulphur	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050

Condition of material on delivery. *a.* Bars and billets shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

En 36A, 36B, 36C

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.
Refine at a temperature 850/880°C., cool in air, oil or water.
Harden in oil from a temperature of 760/780°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	En 36A	En 36B	En 36C
Tensile strength, tons/sq. in., min.	55	65	65
Elongation, per cent, min.	15	13	13
Izod impact value, ft. lb., min.	35	30	30

* See Appendix A for 'single quench' treatment

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

5 PER CENT NICKEL CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP-FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 40 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.16
Silicon	0.10	0.35
Manganese	—	0.45
Nickel	4.50	5.20
Chromium	—	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bar and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880° and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 750/780°C.

* See Appendix A for 'single quench' treatment

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	40
Elongation, per cent, min.	20
Izod impact value, ft. lb., min.	50

5 PER CENT NICKEL MOLYBDENUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP-FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 65 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.16
Silicon	0.10	0.35
Manganese	—	0.60
Nickel	4.50	5.50
Chromium	—	0.30
Molybdenum	0.15	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

a. Condition of material on delivery. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air or oil.

Harden in oil from a temperature of 750/780°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in.	65
Elongation, per cent, min.	13
Izod impact value, ft. lb., min.	30

4¼ PER CENT NICKEL-CHROMIUM AND NICKEL-CHROMIUM-MOLYBDENUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 85 tons/sq. in. min

Chemical composition. The steel shall contain :

Element	En 39A		En 39B	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.12	0.18	0.12	0.18
Silicon	0.10	0.35	0.10	0.35
Manganese	—	0.50	—	0.50
Nickel	3.80	4.50	3.80	4.50
Chromium	1.00	1.40	1.00	1.40
Molybdenum	—	—	0.15	0.35
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the softened condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the test pieces, selected and prepared as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows.—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air or oil.

Harden in oil from a temperature of 760/780°C.

Temper at a temperature not exceeding 200°C.

Mechanical properties. *a.* The mechanical properties obtained from samples selected and prepared as stated in the appropriate general clauses and treated in test piece size shall be as follows:—

Tensile strength, tons/sq. in., min. 85

Elongation, per cent, min. 12

Izod impact value, ft. lb. min. 25

b. In the softened condition the material shall have a Brinell hardness number not exceeding 277.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser, the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

3 PER CENT CHROMIUM-MOLYBDENUM NITRIDING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 45/55(R), 50/60(S), 55/65(T) and 60/70(U) tons/sq. in. The purchaser should state on the order the condition, R, S, T or U, for which the material is ultimately required. The selection of En 40A or En 40B will be governed by the tensile range required.

Chemical composition. The steel shall contain :

Element	En 40A		En 40B	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.10	0.20	0.20	0.30
Silicon	0.10	0.35	0.10	0.35
Manganese	0.40	0.65	0.40	0.65
Nickel	—	0.40	—	0.40
Chromium	2.90	3.50	2.90	3.50
Molybdenum	0.40	0.70	0.40	0.70
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop forgings shall be delivered in the hardened and tempered condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the hardened and tempered condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 880/910°C.

Temper at a suitable temperature between 570°C. and 750°C.

When so required by the purchaser, this is to be followed by a stabilising treatment, after rough machining, at a temperature not lower than 520°C, and afterwards the parts shall be nitrogen hardened by an approved process.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be tested either in the hardened and tempered condition, or, by arrangement with the purchaser, may be tested either after a stabilising treatment or after a blank nitriding treatment.

The mechanical properties then obtained shall be as follows :—

Property	Hardened and tempered condition			
	R	S	T	U
Limiting ruling section, in.	6	6	6	6
Tensile strength, tons/sq. in., min.	45	50	55	60
Yield stress, tons/sq. in., min.	34	38	44	48
Elongation, per cent, min.	22	20	18	17
Izod impact value, ft. lb., min.	40	40	40	35
Brinell hardness number	201 255	223 277	248 302	269 321

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition			
	R	S	T	U
Proof stress (0.2 per cent), tons/sq. in., min.	32	36	41	46

**3 PER CENT CHROMIUM-MOLYBDENUM-VANADIUM
NITRIDING STEEL (HIGHER TENSILE)**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

This steel is suitable where a higher core strength is required for nitriding than is provided by En 40B, and the purchaser is recommended to consult the manufacturer regarding the use of this steel.

Chemical composition. The steel shall contain

Element	Per cent	
	min.	max
Carbon	0.30	0.50
Silicon	0.10	0.35
Manganese	0.40	0.80
Nickel	—	0.40
Chromium	2.50	3.50
Molybdenum	0.70	1.20
Vanadium	0.10	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop forgings shall be delivered in the softened condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test pieces, selected and prepared as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows:—

Harden in oil from a temperature of 900/940°C.

Temper at a suitable temperature between 570°C. and 650°C.

When so required by the purchaser, this is to be followed by a stabilising treatment, after rough machining, at a temperature not lower than 520°C., and afterwards the parts shall be nitrogen hardened by an approved process.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be tested either in the hardened and tempered condition, or, by arrangement with the purchaser, may be tested either after a stabilising treatment or after a blank nitriding treatment.

The mechanical properties then obtained shall be as follows:—

Limiting ruling section in.	2½
Tensile strength, tons/sq. in., min.	85
Yield stress, tons/sq. in., min.	72
Elongation, per cent, min.	10
Izod impact value, ft. lb., min.	15
Brinell hardness number	375/444

NOTE. When proof stress tests are specifically requested in the enquiry and order, the value shall be as follows:—

Proof stress (0.2 per cent) tons/sq. in., min.	68
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**1½ PER CENT CHROMIUM-ALUMINIUM-MOLYBDENUM
NITRIDING STEEL**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 45/55(R), 50/60(S) and 55/65(T) tons/sq. in.
The purchaser should state on the order the condition, R, S or T, for which the material is ultimately required
The selection of En 41A or En 41B will be governed by the tensile range required.

Chemical composition. The steel shall contain :

Element	En 41A		En 41B	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.25	0.35	0.35	0.45
Silicon	0.10	0.45	0.10	0.45
Manganese	—	0.65	—	0.65
Nickel	—	0.40	—	0.40
Chromium	1.40	1.80	1.40	1.80
Molybdenum	0.10	0.25	0.10	0.25
Aluminium	0.90	1.30	0.90	1.30
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Condition of material on delivery. *a* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b Forgings and drop-forgings shall be delivered in the hardened and tempered condition, unless the order states otherwise.

c Bars for machining shall be delivered in the hardened and tempered condition, unless the order states otherwise.

d Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 880/910°C.

Temper at a suitable temperature between 550°C. and 720°C.

When so required by the purchaser, this is to be followed by a stabilising treatment, after rough machining, at a temperature not lower than 520°C., and afterwards the parts shall be nitrogen hardened by an approved process.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be tested either in the hardened and tempered condition, or by arrangement with the purchaser, may be tested after either a stabilising treatment or after a blank nitriding treatment. The mechanical properties are as follows:—

Property	Hardened and tempered condition		
	R	S	T
Limiting ruling section, in	6	4	2½
Tensile strength, tons/sq in., min	45	50	55
Yield stress, tons/sq. in., min.	34	38	44
Elongation, per cent, min.	20	19	17
Izod impact value, ft. lb., min.	40	40	35
Brinell hardness number	201/255	223/277	248/302

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition		
	R	S	T
Proof stress (0.2 per cent), tons/sq in., min	32	9	41

En 42, 42B, 42C, 42D, 42E,
42F, 42G, 42J

CARBON SPRING STEEL

BARS FOR OIL-HARDENING AND TEMPERING

En 42 **Chemical composition.** The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.70	0.85
Silicon	0.10	0.40
Manganese	0.55	0.75
Sulphur	—	0.050
Phosphorus	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C.

En 42B, 42C, 42D Steel of this type may be required in the form of wire for oil-hardened and tempered springs (see B.S. 1429, 'Annealed steel wire for oil-hardened and tempered springs'). The compositions of these steels are as follows:—

Element	En 42B		En 42C		En 42D	
	Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.
Carbon	0.60	0.70	0.70	0.80	0.80	0.90
Silicon	—	0.35	—	0.35	—	0.35
Manganese	0.55	0.80	0.55	0.80	0.55	0.80
Sulphur	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050

En 42, 42B, 42C, 42D, 42E,
42F, 42G, 42J

Steel of this type may be required in the form of cold rolled strip and flat wire for hardening and tempering (see B.S. 1429, 'Steel plate, sheet and strip'). The compositions of these steels are as follows:—

Element	En 42E		En 42F		En 42G		En 42J	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.60	0.75	0.60	0.75	0.75	0.90	0.75	0.90
Silicon	—	0.35	—	0.35	—	0.35	—	0.35
Manganese	0.30	0.60	0.60	0.90	0.30	0.60	0.60	0.90
Sulphur	—	0.050	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050	—	0.050

CARBON SPRING STEEL
BARS FOR WATER HARDENING AND TEMPERING

Chemical composition. The steel shall contain :

En 43

Element	Per cent	
	min.	max.
Carbon	0.45	0.60
Silicon	0.10	0.40
Manganese	0.60	0.80
Sulphur	—	0.050
Phosphorus	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C.

Steel of this type may be required in the form of cold rolled strip and flat En 43G, wire for hardening and tempering (see B.S. 1449, 'Steel plate, sheet and 43J strip'). The compositions of these steels are as follows:—

Element	En 43G		En 43J	
	min.	max.	min.	max.
Carbon	0.45	0.60	0.45	0.60
Silicon	—	0.35	—	0.35
Manganese	0.30	0.60	0.60	0.90
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

' 50 ' CARBON STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 43A Suitable in the hardened and tempered condition for tensile ranges of 45/55(R) and 50/60(S) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the conditions, normalised, cold drawn, or hardened and tempered, R or S, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.45	0.55
Silicon	0.05	0.35
Manganese	0.70	1.00
Sulphur	—	0.060
Phosphorus	—	0.060

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the condition stated on the order

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

a. Material required in the normalised condition .

Normalise at a temperature of 810/840°C.

b. Material required in the hardened and tempered condition .

Harden in oil from a temperature of 810/840°C.

Temper at a temperature of 550/660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows —

NORMALISED OR HARDENED AND TEMPERED

Property	Condition		
	Normalised	Hardened and tempered	
		R	S
Limiting ruling section, in	1½	2	1½
Tensile strength, tons/sq. in., min	40	45	50
Yield stress, tons/sq. in., min	21	30	33
Elongation, per cent, min.	18	18	18
Brinell hardness number	179/229	201/255	223/277

NOTE. When proof stress tests are specifically requested in the enquiry and order, the value shall be as follows :—

Property	Hardened and tempered condition	
	R	S
Proof stress (0.2 per cent), tons/sq. in., min	28	31

COLD DRAWN

Maximum size (diameter or width across flats) in.	2
Tensile strength, tons/sq. in.	min 45 max 60
Elongation, per cent, min.	12
Brinell hardness number	201/277

En 43A, 43B, 43C, 43D, 43E

En 43B, Steel of this type may be ordered to specification En 43B, En 43C, En 43D or En 43E, when it will be supplied to a specified composition only, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specifications En 43B, En 43C, En 43D and En 43E.

Element	En 43B		En 43C		En 43D		En 43E	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.45	0.50	0.50	0.55	0.60	0.65	0.65	0.70
Silicon	0.05	0.35	0.05	0.35	0.05	0.35	0.05	0.35
Manganese	0.70	1.00	0.70	1.00	0.40	0.60	0.70	0.90
Sulphur	—	0.060	—	0.060	—	0.060	—	0.060
Phosphorus	—	0.060	—	0.060	—	0.060	—	0.060

En 44, 44B, 44C, 44D, 44E

CARBON SPRING STEEL (HIGHER CARBON CONTENT)

BARS FOR OIL HARDENING AND TEMPERING

En 44 Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.90	1.20
Silicon	—	0.30
Manganese	0.45	0.70
Sulphur	—	0.050
Phosphorus	—	0.050

En 44B, Steel of this type may be required in the form of wire for oil-hardened and tempered springs (see B.S. 1429, 'Annealed steel wire for oil-hardened and tempered springs').

44C

The compositions of these steels are as follows :—

Element	En 44B		En 44C	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.90	1.00	1.00	1.20
Silicon	—	0.35	—	0.35
Manganese	0.40	0.70	0.40	0.70
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

En 44, 44B, 44C, 44D, 44E

Steel of this type may be required in the form of cold rolled strip and En 44D, flat wire for hardening and tempering (see B.S. 1449, 'Steel plate, sheet 44E and strip'). The compositions of these steels are as follows :—

Element	En 44D		En 44E	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.90	1.05	1.05	1.25
Silicon	—	0.35	—	0.35
Manganese	0.30	0.70	0.30	0.70
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

En 45, 45A

SILICON-MANGANESE SPRING STEEL
BARS FOR OIL HARDENING AND TEMPERING

Chemical composition. The steel shall contain :

Element	En 45		En 45A	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.50	0.60	0.55	0.65
Silicon	1.50	2.00	1.70	2.00
Manganese	0.70	1.00	0.70	1.00
Sulphur	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C. Steel of this type may also be required in the form of wire for oil-hardened and tempered springs (see B.S. 1429, 'Annealed steel wire for oil-hardened and tempered springs').

En 46

SILICON-MANGANESE SPRING STEEL
BARS FOR WATER HARDENING AND TEMPERING

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	1.50	2.00
Manganese	0.70	1.00
Sulphur	—	0.050
Phosphorus	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C.

En 47

1 PER CENT CHROMIUM-VANADIUM SPRING STEEL
BARS FOR OIL HARDENING AND TEMPERING

Chemical composition. The steel shall contain .

Element	Per cent	
	min.	max.
Carbon	0.45	0.55
Silicon	—	0.50
Manganese	0.50	0.80
Chromium	0.80	1.20
Vanadium	0.15	—
Sulphur	—	0.050
Phosphorus	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C. Steel of this type may also be required in the form of wire for oil-hardened and tempered springs (see B.S. 1429, 'Annealed steel wire for oil-hardened and tempered springs').

1 PER CENT CHROMIUM SPRING STEEL
BARS FOR OIL HARDENING AND TEMPERING

En 48

Chemical composition. The steel shall contain .

Element	Per cent	
	min.	max.
Carbon	0.45	0.55
Silicon	0.10	0.50
Manganese	0.50	0.80
Chromium	1.00	1.40
Sulphur	—	0.050
Phosphorus	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C.

SILICON-CHROMIUM SPRING STEEL
BARS FOR OIL HARDENING AND TEMPERING

Chemical composition. The steel shall contain :

Element	Per cent	
	min	max.
Carbon	0.50	0.60
Silicon	1.35	1.65
Manganese	0.60	0.90
Chromium	0.55	0.85
Sulphur	—	0.050
Phosphorus	—	0.050

Dimensions. Laminated spring plates to this specification shall conform to the dimensional requirements in Appendix C.

CHROMIUM-VANADIUM STEEL FOR WIRE FOR
VALVE SPRINGS

This steel is required in the form of annealed wire for oil-hardened and tempered springs and is covered in B.S. 1429, 'Annealed steel wire for oil-hardened and tempered springs.' The composition is as follows. —

Element	Per cent	
	min.	max.
Carbon	0.40	0.50
Silicon	0.10	0.35
Manganese	0.50	0.70
Chromium	1.00	1.50
Vanadium	0.15	—
Sulphur	—	0.040
Phosphorus	—	0.040

En 49A,
49B,
49C,
49D

CARBON STEELS FOR HARD DRAWN WIRE

These steels are required in the form of hard drawn wire for springs and are covered in B.S. 1408, 'Hard drawn steel wire for springs.' The compositions are as follows :—

Element	En 49A		En 49b		En 49C		En 49D	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.40	0.85	0.45	0.85	0.55	0.85	0.65	0.85
Silicon	—	0.30	—	0.30	—	0.30	—	0.30
Manganese	—	1.00	—	1.00	—	0.75	—	0.75
Sulphur	—	0.050	—	0.050	—	0.040	—	0.040*
Phosphorus	—	0.050	—	0.050	—	0.040	—	0.040*

* By agreement between purchaser and manufacturer steel to En 49D may be supplied with sulphur and phosphorus contents each 0.030 per cent max.

3 PER CENT NICKEL VALVE STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.25	0.35
Silicon	0.10	0.35
Manganese	0.35	0.75
Nickel	2.75	3.25
Chromium	—	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or water from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 650°C.

Mechanical properties. The test samples from bars and billets for forging over 1½ in. diameter shall be forged or machined to 1½ in. diameter and heat treated in that size, and bars of 1½ in. diameter and under shall be heat treated in the full size.

The test pieces from forgings and drop-forgings and from bars for machining shall be selected and prepared as stated in the appropriate general clauses.

The mechanical properties shall be as follows :—

Izod impact value, ft. lb., min. 40
Brinell hardness number, max. 229

SILICON-CHROMIUM VALVE STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.40	0.50
Silicon	3.00	3.75
Manganese	0.30	0.60
Nickel	—	0.50
Chromium	7.50	9.50
Sulphur	—	0.040
Phosphorus	—	0.040

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or air from a temperature of 1000/1050°C.

Temper at a suitable temperature between 650°C. and 850°C.

Mechanical properties. The mechanical properties shall be as follows :—

Brinell hardness number 255/293

SILICON-CHROMIUM VALVE STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP-FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Chemical composition. The steel shall contain .

Element	Per cent	
	min.	max.
Carbon	0.55	0.65
Silicon	1.40	1.70
Manganese	0.30	0.60
Nickel	—	0.50
Chromium	5.75	6.75
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

· Harden in oil or air from a temperature of 950/1000°C.

Temper at a suitable temperature between 720°C. and 800°C.

Mechanical properties. The test samples from bars and billets for forging over 1 1/2 in. diameter shall be forged or machined to 1 1/2 in. diameter and heat treated in that size, and bars of 1 1/2 in. diameter and under shall be heat treated in the full size.

The test pieces from forgings and drop-forgings and from bars for machining shall be selected and prepared as stated in the appropriate general clauses. The mechanical properties shall be as follows :—

Izod impact value, ft. lb., min. 12

Brinell hardness number 235/285

HIGH NICKEL-CHROMIUM-TUNGSTEN VALVE STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Chemical composition. The steel shall contain :

Element	En 54		En 54A	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	0.35	0.50	0.37	0.47
Silicon	1.00	2.50	1.00	2.00
Manganese	—	1.50	0.50	0.80
Nickel	10.0	—	13.0	15.0
Chromium	12.00	16.0	13.0	15.0
Tungsten	2.00	4.00	2.2	3.0
Molybdenum (if specified)	—	—	0.40	0.60
Niobium (if specified)	—	—	0.16	0.22
Sulphur	—	0.045	—	0.045
Phosphorus	—	0.045	—	0.045

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Soften by cooling freely in air or quenching in oil or water (at the option of the manufacturer) from a temperature of 950/1020°C.

Mechanical properties. The test samples from bars and billets for forging over 1½ in. diameter shall be forged or machined to 1½ in. diameter and heat treated in that size, and bars of 1½ in. diameter and under shall be heat treated in the full size

The test pieces from forgings and drop-forgings and from bars for machining shall be selected and prepared as stated in the appropriate general clauses.

The mechanical properties shall be as follows :—

Property	En 54	En 54A
Izod impact value, ft lb, min.	15	15
Brinell hardness number, max.	302	269

HIGH CHROMIUM-NICKEL-TUNGSTEN VALVE STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP-FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Chemical composition. The steel shall contain :

Element	Per cent	
	min	max
Carbon	0.18	0.45
Silicon	1.00	2.50
Manganese	—	1.00
Nickel	6.00	12.0
Chromium	17.0	—
Tungsten	2.00	4.00
Sulphur	—	0.045
Phosphorus	—	0.045

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Soften by cooling freely in air or quenching in oil or water (at the option of the manufacturer) from a temperature of 950/1020°C.

Mechanical properties. The test samples from bars and billets for forging over 1½ in. diameter shall be forged or machined to 1½ in. diameter and heat treated in that size, and bars of 1½ in. diameter and under shall be heat treated in the full size. The test pieces from forgings and drop-forgings and from bars for machining shall be selected and prepared as stated in the appropriate general clauses.

The mechanical properties shall be as follows :—

Izod impact value, ft. lb., min.	20
Brinell hardness number, max.	302

CHROMIUM RUST-RESISTING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS*As
altered
June,
1958*

En 56. The range of composition of En 56 which is sub-divided into Grades En 56A, En 56B, En 56C, En 56D is suitable for tensile ranges of 35/45 (P), 45/55 (R), 50/60 (S), 55/65 (T) and 75/85 (X) tons/sq.in. The purchaser should state on the order the condition P, R, S, T, or X for which the material is ultimately required and the ruling section at the time of heat treatment. The selection of En 56A, En 56B, En 56C or En 56D will be governed by the ruling section and the tensile range required, and unless otherwise agreed will be at the discretion of the steel maker.

Chemical composition. The steel shall contain :

Element	En 56A		En 56B		En 56C		En 56D	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	—	0.12	0.12	0.18	0.18	0.25	0.25	0.35
Silicon	—	1.00	—	1.00	—	1.00	—	1.00
Manganese	—	1.00	—	1.00	—	1.00	—	1.00
Nickel	—	1.00	—	1.00	—	1.00	—	1.00
Chromium	12.0	14.0	12.0	14.0	12.0	14.0	12.0	14.0
Sulphur	—	0.045	—	0.045	—	0.045	—	0.045
Phosphorus	—	0.045	—	0.045	—	0.045	—	0.045

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or air from a temperature of 950/1020°C
Temper at a suitable temperature not exceeding 750°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition									
	P		R		S		T	X		
Limiting ruling section, in	6	2	6	2	4	2	2	1½		
Tensile strength, tons/sq in., min.	35	35	45	45	50	50	55	75		
Yield stress, tons/sq. in., min.	25	25	34	34	38	38	44	63		
Elongation, per cent, min.	25	25	20	20	16	16	12	8		
Izod impact value, ft. lb., min	25	45	20	25	10	20	10	—		
Brinell hardness number	152/207	152/207	201/255	201/255	223/277	223/277	248/302	341 min.		

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition				
	P	R	S	T	X
Proof stress (0.2 per cent), tons/sq. in., min.	23	32	36	41	59

NOTE. When these steels are required in the form of plate, sheet and strip, they should be ordered to B.S. 1449, 'Steel plate, sheet and strip'. When they are required in the form of wire they should be ordered to B.S. 1554, 'Rust, acid and heat resisting steel wire' or B.S. 2056, 'Rust, acid and heat resisting steel wire for springs' as appropriate.

En 56AM, 56BM, 56CM, 56DM

CHROMIUM RUST-RESISTING STEEL
(FREE MACHINING)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

These free machining modifications of En 56B, 56C and 56D are suitable for tensile ranges of 35/45 (P), 45/55 (R) and 50/60 (S) tons./sq. in. The purchaser should state on the order the condition, P, R or S; for which the material is ultimately required. The selection of En 56AM, En 56BM, En 56CM or En 56DM will be governed by the tensile range required.

Chemical composition. The steel shall contain :

Element	En 56AM		En 56BM		En 56CM		En 56DM	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	—	0.12	0.12	0.18	0.18	0.25	0.25	0.35
Silicon	—	1.00	—	1.00	—	1.00	—	1.00
Manganese	—	1.50	—	1.50	—	1.50	—	1.50
Nickel	—	1.00	—	1.00	—	1.00	—	1.00
Chromium	12.0	14.0	12.0	14.0	12.0	14.0	12.0	14.0
Molybdenum*	—	0.60	—	0.60	—	0.60	—	0.60
Sulphur	—	0.75	—	0.75	—	0.75	—	0.75
Selenium*	—	0.60	—	0.60	—	0.60	—	0.60
Zirconium*	—	0.60	—	0.60	—	0.60	—	0.60
Lead*	—	0.35	—	0.35	—	0.35	—	0.35
Phosphorus	—	0.045	—	0.045	—	0.045	—	0.045

* Total 1.00 per cent max

En 56AM, 56BM, 56CM, 56DM

- Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.
b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.
c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.
d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or air from a temperature of 950/1020°C
Temper at a suitable temperature not exceeding 750°C.

Mechanical properties. The mechanical properties obtained from the test pieces as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition		
	P	R	S
Limiting ruling section, in	6	6	4
Tensile strength, tons/sq. in, min.	35	45	50
Elongation, per cent, min.	20	15	12
Izod impact value, ft lb, min.	25	20	—
Brinell hardness number	152/207	201/255	223/277

NOTE. When these steels are required in the form of plate, sheet and strip they should be ordered to B S 1449, 'Steel plate, sheet and strip'. When they are required in the form of wire they should be ordered to B S 1554, 'Rust, acid and heat resisting steel wire'.

**MARTENSITIC CHROMIUM-NICKEL RUST RESISTING
STEEL**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 55 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.25
Silicon	0.10	1.00
Manganese	—	1.00
Nickel	1.00	3.00
Chromium	15.5	20.0
Sulphur	—	0.045
Phosphorus	—	0.045

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or air from a temperature of 950/1020°C.

Temper at a suitable temperature between 550°C. and 650°C.

Mechanical properties. The mechanical properties obtained from test pieces selected and tested as stated in the appropriate general clauses shall be as follows :—

Limiting ruling section, in	6	2½
Tensile strength, tons/sq. in., min	55	55
Yield stress, tons/sq. in., min	44	44
Elongation, per cent, min	15	15
Izod impact value, ft. lb., min.	15	25
Brinell hardness number, min.	248	248

NOTE 1. When proof stress tests are specifically requested in the enquiry and order, the value shall be as follows :—

Proof stress (0.2 per cent), tons/sq. in., min. 41

NOTE 2. When this steel is required in the form of plate, sheet and strip it should be ordered to B.S. 1449, 'Steel plate, sheet and strip'. When it is required in the form of wire it should be ordered to B.S. 1554 'Rust, acid and heat resisting steel wire' or B.S. 2056, 'Rust, acid and heat resisting steel wire for springs' as appropriate.

En 58A, 58B, 58C, 58D, 58E,
58F, 58G, 58H, 58J, 58M

**AUSTENITIC CHROMIUM-NICKEL RUST,
ACID AND HEAT RESISTING STEEL**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 35 tons/sq. in., min.

En 58A, Chemical composition. The steel shall contain :

Element	En 58A		En 58B		En 58C		En 58E	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	—	0.16	—	0.15	—	0.15	—	0.08
Silicon	0.20	—	0.20	—	0.20	—	0.20	—
Manganese	—	2.00	—	2.00	—	2.00	—	2.00
Nickel	7.0*	10.0	7.0*	10.0	9.0	12.0	8.0	11.0
Chromium	17.0*	20.0	17.0*	20.0	17.0	20.0	17.5	20.0
Titanium	—	—	†	—	†	—	—	—
Sulphur	—	0.045	—	0.045	—	0.045	—	0.045
Phosphorus	—	0.045	—	0.045	—	0.045	—	0.045

Element	En 58F		En 58G		En 58H		En 58J	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	—	0.15	—	0.15	—	0.12	—	0.12
Silicon	0.20	—	0.20	—	0.20	—	0.20	—
Manganese	—	2.00	—	2.00	—	2.00	—	2.00
Nickel	7.0*	10.0	9.0	12.0	8.0	12.0	8.0	12.0
Chromium	17.0*	20.0	17.0	20.0	17.0	20.0	17.0	20.0
Molybdenum	—	—	—	—	1.50	2.50	2.50	3.50
Titanium	—	—	—	—	§	—	§	—
Niobium	†	—	†	—	§	—	§	—
Sulphur	—	0.045	—	0.045	—	0.045	—	0.045
Phosphorus	—	0.045	—	0.045	—	0.045	—	0.045

* The sum of the nickel and chromium contents shall be not less than 25.0 per cent.

† Not less than four times the carbon content.

‡ Not less than eight times the carbon content.

§ These elements may be present at the option of the manufacturer.

En 58A, 58B, 58C, 58D, 58E,
58F, 58G, 58H, 58J, 58M

Condition of material on delivery.

a. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test pieces, selected and prepared as stated in Clause 7, shall be as follows :—

Softened by cooling freely in air or quenching in oil or water (at the option of the manufacturer) from a temperature of 950/1150°C.

Mechanical properties. The mechanical properties obtained from the test pieces, selected and prepared as stated in the appropriate general clauses, shall be as follows :—

Limiting ruling section, in.	6
Tensile strength, tons/sq. in., min.	35
Yield stress, tons/sq. in., min.	12
Elongation, per cent, min.	30
Izod impact value, ft. lb., min.	50

Material to specifications En 58B, 58C, 58F and 58G, and to specifications En 58H and 58J when stabilized with titanium or niobium, shall satisfy a special ringing and bend test, which shall be carried out as follows :—

Each bend test piece shall be not larger than ½ in. diameter or thickness.

The test piece shall be heated for 30 minutes at a temperature of 650°C. and cooled in air and shall then be immersed for 72 hours in a boiling solution having the following composition :—

111 grammes copper sulphate (Cu SO₄ · 5H₂O)
98 grammes sulphuric acid (sp. gr. 1.84)
made up to 1 litre with distilled water.

Precautions should be taken during boiling to prevent concentration due to evaporation.

Each test piece shall then be dropped on a metal or stone surface and must emit a clear metallic ring. The test pieces shall then be bent through 90° over a radius of three times the diameter or thickness of the test piece and shall withstand this treatment without cracking.

En 58A, 58B, 58C, 58D, 58E,
58F, 58G, 58H, 58J, 58M

En 58D When the steel is required for deep drawing or spinning purposes it may be ordered to En 58D when the steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.16
Silicon	0.20	—
Manganese	—	2.00
Nickel*	11.0	14.0
Chromium*	11.0	14.0
Sulphur	—	0.045
Phosphorus	—	0.045

* The sum of the nickel and chromium contents shall be not less than 23.0 per cent

En 58M Free machining modifications are obtainable in certain of these grades of austenitic chromium-nickel steels. When the material is required for free machining, it should be ordered to En 58M and steel will be supplied to a composition agreed between the purchaser and the supplier.

NOTE. When steels of the En 58 series are required in the form of plate, sheet and strip they should be ordered to B S. 1449, 'Steel plate, sheet and strip'. When they are required in the form of wire they should be ordered to B S 1554, 'Rust, acid and heat resisting steel wire' or B S 2056 'Rust, acid and heat resisting steel wire for springs' as appropriate

CHROMIUM-NICKEL-SILICON VALVE STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.74	0.84
Silicon	1.75	2.25
Manganese	0.20	0.60
Nickel	1.15	1.65
Chromium	19.0	20.5
Sulphur	—	0.030
Phosphorus	—	0.030

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the condition stated on the order.

Heat treatment. The heat treatment recommended for this steel is as follows :—

Harden in oil or air from a temperature of 1050/1080°C

Temper at a suitable temperature between 700°C. and 750°C.

Mechanical properties. The steel shall be capable of local hardening by oil quenching to a Rockwell C hardness of not less than 47 or the equivalent Vickers hardness number.*

* The equivalent Vickers hardness number recommended in B S 860, 'Approximate comparison of hardness scales' is 480.

**FERRITIC CHROMIUM RUST-RESISTING STEEL
(17 AND 20 PER CENT CHROMIUM)**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Chemical composition. The steel shall contain .

Element	En 60		En 61	
	Per cent		Per cent	
	min.	max.	min.	max.
Carbon	—	0.12	—	0.12
Silicon	—	1.00	—	1.00
Manganese	—	1.00	—	1.00
Nickel	—	0.50	—	0.50
Chromium	16.0	18.0	20.0	22.0
Sulphur	—	0.045	—	0.045
Phosphorus	—	0.045	—	0.045

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment recommended for the steel is as follows :—

Soften by cooling freely in air from a temperature of 700/780°C.

NOTE When these steels are required in the form of plate, sheet and strip they should be ordered to B S 1449, ' Steel plate, sheet and strip .

LOW ALLOY STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), 60/70 (U) and 65/75 (V) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T, U or V, for which the material is ultimately required.

The material covered by this specification is capable of meeting the test requirements of specifications En 16 and En 19, except where these are used for special purposes.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon*	0.35	0.45
Silicon	—	0.50
Manganese	1.20	1.50
Nickel	0.50	1.00
Chromium	0.30	0.60
Molybdenum	0.15	0.25
Sulphur	—	0.050
Phosphorus	—	0.050

* For small ruling sections or lower tensile ranges, or when the steel is to be hardened in water, the carbon content, by agreement between the purchaser and the manufacturer, shall be 0.25/0.35 per cent and the steel will be designated as En 100E.

Condition of material on delivery. a. Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil* from a temperature of 830/860°C.

Temper at a suitable temperature between 550°C. and 660°C.

Steel to En 100E may be hardened in water if suitable precautions are taken.

Mechanical properties. The mechanical properties obtained from test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Limiting ruling section, in.	6	4	2½	1½	1¼
Tensile strength, tons/sq. in., min.	45	50	55	60	65
Yield stress, tons/sq. in., min	34	38	44	48	52
Elongation, per cent, min	22	20	18	17	16
Izod impact value, ft. lb., min.	40	40	40	35	35
Brinell hardness number	201/255	223/277	248/302	269/321	293/341

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition				
	R	S	T	U	V
Proof stress (0.2 per cent), tons/sq. in., min.	32	36	41	46	50

* When parts to En 100E are to be water quenched, this shall be stated on the order and the test bars shall be similarly heat treated.

En 100, 100A, 100B, 100C, 100D, 100E

En 100A, 100B, 100C, 100D, For special applications the steel may be ordered to specification En 100A, En 100B, En 100C or En 100D, when it will be supplied to a specified composition only, the limits of which are given below. Mechanical properties are not part of the contractual obligations of specifications En 100A, En 100B, En 100C and En 100D

Element	En 100A		En 100B		En 100C		En 100D	
	Per cent		Per cent		Per cent		Per cent	
	min.	max.	min.	max.	min.	max.	min.	max.
Carbon	0.25	0.30	0.30	0.35	0.35	0.40	0.40	0.45
Silicon	0.10	0.50	0.10	0.50	0.10	0.50	0.10	0.50
Manganese	1.20	1.50	1.20	1.50	1.20	1.50	1.20	1.50
Nickel	0.50	1.00	0.50	1.00	0.50	1.00	0.50	1.00
Chromium	0.30	0.60	0.30	0.60	0.30	0.60	0.30	0.60
Molybdenum	0.15	0.25	0.15	0.25	0.15	0.25	0.15	0.25
Sulphur	—	0.050	—	0.050	—	0.050	—	0.050
Phosphorus	—	0.050	—	0.050	—	0.050	—	0.050

LOW NICKEL-CHROMIUM-MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for tensile ranges of 50/60 (S), 55/65 (T), 60/70 (U), 65/75 (V) and 70/80 (W) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, S, T, U, V or W, for which the material is ultimately required.

The material covered by this specification is capable of meeting the test requirements of specifications En 16, En 17, and En 19.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.40	0.80
Nickel	1.20	1.60
Chromium	0.90	1.40
Molybdenum	0.10	0.20
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil from a temperature of 820/850°C
Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition				
	S	T	U	V	W
Limiting ruling section, in.	6	4	2½	1½	1½
Tensile strength, tons/sq. in., min.	50	55	60	65	70
Yield stress, tons/sq. in., min.	38	44	48	52	58
Elongation, per cent. min.	20	18	17	16	15
Izod impact value ft. lb., min.	40	40	35	35	30
Brinell hardness number	223 277	248 302	269 321	293 341	311 375

When supplied in the softened condition the material shall have a Brinell hardness number not exceeding 269.

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition				
	S	T	U	V	W
Proof stress (0.2 per cent), tons/sq. in., min.	36	41	46	50	55

LOW NICKEL-CHROMIUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 111 Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T), and 60/70 (U) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T or U, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.30	0.40
Silicon	0.10	0.35
Manganese	0.60	0.90
Nickel	1.00	1.50
Chromium	0.45	0.75
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or water from a temperature of 820/850°C.
Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test-pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition			
	R	S	T	U
Limiting ruling section, in.	6	4	2½	1¾
Tensile strength, tons/sq. in., min.	45	50	55	60
Yield stress, tons/sq. in., min.	34	38	44	48
Elongation, per cent, min.	22	20	18	17
Izod impact value, ft. lb., min.	40	40	40	35
Brinell hardness number	201/255	223/277	248/302	269/321

NOTE. When proof stress tests are specifically requested in the enquiry and order, the values shall be as follows :—

Property	Hardened and tempered condition			
	R	S	T	U
Proof stress (0.2 per cent), tons/sq. in., min.	32	36	41	46

For special applications the steel may be ordered to specification En 111A, when it will be supplied to a specified composition only, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specification En 111A.

Element	Per cent	
	min.	max.
Carbon	0.33	0.38
Silicon	0.10	0.35
Manganese	0.60	0.90
Nickel	1.00	1.50
Chromium	0.45	0.75
Sulphur	—	0.050
Phosphorus	—	0.050

2 PER CENT NICKEL MOLYBDENUM STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

En 160 Suitable for tensile ranges of 45/55 (R), 50/60 (S), 55/65 (T) and 60/70 (U) tons/sq. in. according to the ruling section of the part. The purchaser should state on the order the condition, R, S, T or U, for which the material is ultimately required.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.35	0.45
Silicon	0.10	0.35
Manganese	0.30	0.60
Nickel	1.50	2.00
Molybdenum	0.20	0.35
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the finally heat treated condition, unless the order states otherwise.

d. Bright bars shall be delivered in the finally heat treated condition, heat treatment being given either before or after any cold work at the option of the manufacturer, unless the order states otherwise.

Heat treatment. The heat treatment to be given to the test bars, selected as stated in Clause 7, and to material supplied in the finally heat treated condition, shall be as follows :—

Harden in oil or water from a temperature of 830/860°C.
Temper at a suitable temperature between 550°C. and 660°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Property	Hardened and tempered condition			
	R	S	T	U
Limiting ruling section, in.	6	4	2½	1½
Tensile strength, tons/sq. in., min.	45	50	55	60
Yield stress, tons/sq. in., min.	34	38	44	48
Elongation, per cent, min.	22	20	18	17
Izod impact value, ft. lb., min.	40	40	40	35
Brinell hardness number	201/255	223/277	248/302	269/321

NOTE. When proof stress tests are specifically requested in the enquiry and order the values shall be as follows :—

Property	Hardened and tempered condition			
	R	S	T	U
Proof stress (0.2 per cent), tons/sq. in., min.	32	36	41	46

For special applications the steel may be ordered to specification En 160A, when it will be supplied to a specified composition only, the limits of which are shown below. Mechanical properties are not part of the contractual obligations of specification En 160A.

Element	Per cent	
	min.	max.
Carbon	0.38	0.43
Silicon	0.10	0.35
Manganese	0.30	0.60
Nickel	1.50	2.00
Molybdenum	0.20	0.35
Sulphur	—	0.050
Phosphorus	—	0.050

CARBON-MANGANESE CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 40 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.18
Silicon	0.05	0.35
Manganese	1.10	1.50
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered in the cold worked or bright machined condition, unless the order states otherwise.

Heat treatment.*† The heat treatment to be given to the 1 3/8 in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C. and cool in air, oil or water.

Harden in oil or water from a temperature of 770/790°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	40
Elongation, per cent, min.	20
Izod impact value, ft. lb., min.	40

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period

CARBON-MANGANESE CASE-HARDENING STEEL
(SEMI-FREE CUTTING)

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

(For this type of steel in the cold drawn condition see En 7A)

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.18
Silicon	0.05	0.35
Manganese	1.20	1.50
Sulphur	0.10	0.18
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered in the cold worked or bright machined condition, unless the order states otherwise.

Heat treatment.*† The heat treatment to be given to the 1 3/8 in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C., cool in air, oil or water.

Harden in oil or water from a temperature of 770/790°C.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	38
Elongation, per cent, min.	20
Izod impact, ft. lb., min.	30

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted or modified to a short heating period.

LOW CHROMIUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

This steel is used to a limited extent for special applications, where a hard case is essential and the mechanical properties of the core are of minor importance. The steel will be supplied to a specified composition only, the limits of which are as follows :—

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.12	0.17
Silicon	0.10	0.35
Manganese	0.30	0.50
Chromium	0.30	0.50
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.* The heat treatment recommended for this steel is as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C., cool in air, oil or water.

Harden in water from a temperature of 760/780°C.

* See Appendix A for 'single quench' treatment.

LOW CHROMIUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

This steel is used to a limited extent for special applications, where a hard case is essential and the mechanical properties of the core are of minor importance. The steel will be supplied to a specified composition only, the limits of which are as follows :—

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	0.16	0.21
Silicon	0.10	0.35
Manganese	0.60	0.80
Chromium	0.60	0.80
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.* The heat treatment recommended for this steel is as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 870/900°C., cool in air, oil or water.

Harden in water from a temperature of 760/780°C.

* See Appendix A for 'single quench' treatment.

**LOW NICKEL-CHROMIUM-MOLYBDENUM
CASE-HARDENING STEEL**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP-FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 55 tons/sq. in. min.

Chemical composition. The steel shall contain :

Element	Per cent	
	min.	max.
Carbon	—	0.22
Silicon	0.10	0.35
Manganese	0.45	0.65
Nickel	1.50	2.00
Chromium	0.40	0.60
Molybdenum	0.20	0.30
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars, selected as stated in Clause 7, and to material required in the finally heat treated condition, shall be as follows :—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 770/800°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be made on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :—

Tensile strength, tons/sq. in., min.	55
Elongation, per cent, min.	15
Izod impact value, ft. lb., min	30

¾ PER CENT NICKEL-CHROMIUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 45 tons/sq. in. min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	—	0.20
Silicon	—	0.35
Manganese	0.60	1.00
Nickel	0.60	1.00
Chromium	0.40	0.80
Molybdenum	—	0.10
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows.

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 780/820°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Tensile strength, tons/sq. in., min.	45
Elongation, per cent, min.	18
Izod impact value, ft. lb., min.	30

1 PER CENT NICKEL-CHROMIUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 55 tons/sq. in. min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max
Carbon	—	0.20
Silicon	—	0.35
Manganese	0.50	1.00
Nickel	0.85	1.25
Chromium	0.60	1.00
Molybdenum	—	0.10
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 780/820°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Tensile strength, tons/sq. in., min.	55
Elongation, per cent, min.	15
Izod impact value, ft. lb., min	20

1½ PER CENT NICKEL-CHROMIUM CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 65 tons/sq. in. min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	—	0.20
Silicon	—	0.35
Manganese	0.50	1.00
Nickel	1.00	1.50
Chromium	0.75	1.25
Molybdenum	0.08	0.15
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air or oil.

Harden in oil from a temperature of 780/820°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Tensile strength, tons/sq. in., min.	65
Elongation, per cent, min.	12
Izod impact value, ft. lb., min.	20

1½ PER CENT NICKEL-CHROMIUM-MOLYBDENUM

CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
 FORGINGS AND DROP FORGINGS
 BARS FOR MACHINING
 BRIGHT BARS

Suitable for a tensile strength of 75 tons/sq. in. min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	—	0.20
Silicon	—	0.35
Manganese	0.50	1.00
Nickel	1.50	2.00
Chromium	0.75	1.25
Molybdenum	0.10	0.20
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the softened condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the 1½ in. diameter test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air or oil.

Harden in oil from a temperature of 780/820°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. *a.* The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Tensile strength, tons/sq. in. min.	75
Elongation, per cent, min.	12
Izod impact value, ft lb, min.	20

b. In the softened condition, the material shall have a Brinell hardness number not exceeding 277.

**2 PER CENT NICKEL-CHROMIUM-MOLYBDENUM
CASE-HARDENING STEEL (LOW CHROMIUM)**

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 85 tons/sq. in. min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	—	0.20
Silicon	—	0.35
Manganese	0.40	0.70
Nickel	1.80	2.20
Chromium	1.40	1.70
Molybdenum	0.15	0.25
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered in the softened condition, unless the order states otherwise.

c. Bars for machining shall be delivered in the softened condition, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the test pieces selected and prepared as stated in Clause 7, and to the material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air or oil.

Harden in oil from a temperature of 780/820°C.

Temper at a temperature not exceeding 200°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. *a.* The mechanical properties obtained from the samples selected and prepared as stated in the appropriate general clauses, and treated in test piece size, shall be as follows:—

Tensile strength, tons/sq. in, min.	85
Elongation, per cent, min.	12
Izod impact value, ft lb., min	25

b. In the softened condition, the material shall have a Brinell hardness number not exceeding 277.

· 15' CARBON LOW ALLOY CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 45 tons/sq in min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	0.13	0.17
Silicon	—	0.35
Manganese	0.70	1.00
Nickel	0.40	0.70
Chromium	0.55	0.80
Molybdenum	0.08	0.15
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. a Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 780/820°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Tensile strength, tons/sq. in., min.	45
Elongation, per cent, min.	18
Izod impact value, ft. lb., min.	25

' 20 ' CARBON LOW ALLOY CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 55 tons/sq. in. min.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	0.18	0.23
Silicon	—	0.35
Manganese	0.70	1.00
Nickel	0.40	0.70
Chromium	0.55	0.80
Molybdenum	0.08	0.15
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer

Heat treatment.*† The heat treatment to be given to the test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C.

Refine at a temperature of 850/880°C., cool in air, oil or water.

Harden in oil from a temperature of 780/320°C.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period

Mechanical properties. The mechanical properties obtained from the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows:—

Tensile strength, tons/sq. in., min.	55
Elongation, per cent, min.	15
Izod impact value, ft. lb., min.	15

· 25 · CARBON LOW ALLOY CASE-HARDENING STEEL

BARS AND BILLETS FOR FORGING
FORGINGS AND DROP FORGINGS
BARS FOR MACHINING
BRIGHT BARS

Suitable for a tensile strength of 65 tons/sq. in. min.

The steel shall be supplied on tensile strength only or, by special arrangement between the purchaser and manufacturer, on analysis only.

Chemical composition. The steel shall contain:

Element	Per cent	
	min.	max.
Carbon	0.22	0.26
Silicon	—	0.35
Manganese	0.70	1.00
Nickel	0.40	0.70
Chromium	0.55	0.80
Molybdenum	0.08	0.15
Sulphur	—	0.050
Phosphorus	—	0.050

Condition of material on delivery. *a.* Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise.

b. Forgings and drop-forgings shall be delivered as forged, unless the order states otherwise.

c. Bars for machining shall be delivered as rolled, unless the order states otherwise.

d. Bright bars shall be delivered, unless the order states otherwise, in the cold worked condition suitable for machining, and the maximum Brinell hardness number may be agreed between purchaser and manufacturer.

Heat treatment.*† The heat treatment to be given to the test bars selected as stated in Clause 7, and to material required in the finally heat-treated condition, shall be as follows:—

Blank carburise at a temperature between 880°C. and 930°C
Refine at a temperature of 850/880°C., cool in air or oil.
Harden in oil from a temperature of 780/820°C.

Mechanical properties. If the steel is supplied on the basis of tensile strength, the tensile strength obtained from the test pieces selected and prepared as stated in the appropriate general clause shall be not less than 65 tons/sq.in.

* See Appendix A for 'single quench' treatment.

† By arrangement with the purchaser the tests may be carried out on samples from which the blank carburising treatment has been omitted, or modified to a short heating period.

APPENDIX A

ALTERNATIVE TREATMENT FOR CASE-HARDENING STEELS

By suitable selection of composition and method of manufacture it is possible to omit the refining treatment after carburising some types of case-hardening steels. In such cases the treatment after carburising is to reheat the material to the final hardening temperature, usually 760/800°C., and quench in oil or water according to the type of steel employed. Such treatment is referred to as the 'single quench' treatment. It is not recommended that the single quench treatment should be employed except by arrangement with the manufacturer of the steel who would in that case supply a grade of steel suitable for such treatment.

APPENDIX B

TABLE 8. BRITISH STANDARD BRIGHT STEEL BARS FOR THE PRODUCTION OF MACHINED PARTS

ROUND—INCH SIZES
All tolerances + 0.000 inch

Diameter	Tolerance (minus)	Diameter	Tolerance (minus)
in.	in.	in.	in.
below $\frac{1}{4}$	0.002	$1\frac{5}{16}$	0.004
$\frac{1}{4}$ to $\frac{1}{2}$	0.003	$1\frac{1}{2}$	0.004
$1\frac{7}{32}$	0.003	$1\frac{3}{4}$	0.004
$\frac{5}{16}$	0.003	$1\frac{5}{16}$	0.004
$1\frac{9}{32}$	0.003	$1\frac{7}{8}$	0.004
$\frac{3}{8}$	0.003	$1\frac{7}{16}$	0.004
$2\frac{1}{32}$	0.003	2	0.004
$1\frac{1}{16}$	0.003	$2\frac{1}{16}$	0.005
$2\frac{1}{8}$	0.003	$2\frac{1}{4}$	0.005
$\frac{3}{4}$	0.003	$2\frac{3}{8}$	0.005
$2\frac{5}{32}$	0.003	$2\frac{1}{2}$	0.005
$1\frac{3}{16}$	0.003	$2\frac{5}{8}$	0.005
$2\frac{7}{32}$	0.003	$2\frac{3}{4}$	0.005
$\frac{7}{8}$	0.003	$2\frac{7}{8}$	0.005
$2\frac{9}{32}$	0.004	3	0.005
$1\frac{5}{8}$	0.004	$3\frac{1}{4}$	0.005
$3\frac{1}{32}$	0.004	$3\frac{1}{2}$	0.005
1	0.004	$3\frac{3}{4}$	0.005
$1\frac{1}{8}$	0.004	4	0.005
$1\frac{1}{4}$	0.004	$4\frac{1}{4}$	0.006
$1\frac{3}{8}$	0.004	$4\frac{1}{2}$	0.006
$1\frac{1}{2}$	0.004	$4\frac{3}{4}$	0.006
$1\frac{5}{8}$	0.004	5	0.006
$1\frac{3}{4}$	0.004	$5\frac{1}{4}$	0.007
$1\frac{7}{8}$	0.004	Above $5\frac{1}{4}$ in. and increasing in steps of $\frac{1}{4}$ in.	0.007

NOTE. The tolerances given in this table are those acceptable for most uses. For any special application covered by a British Standard the tolerances given in that Standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.

As altered Feb., 1956

B.S. 970 : 1955

TABLE 9. BRITISH STANDARD BRIGHT STEEL BARS FOR THE PRODUCTION OF MACHINED PARTS
 ROUND—METRIC SIZES
 All tolerances + 0.00 mm.

Diameter		Tolerance (minus)
mm.	in. (see note)	mm.
14	0.5512	0.08 (0.00315 in.)
15	0.5906	0.08
18	0.7087	0.08
20	0.7874	0.08
22	0.8661	0.08
25	0.9843	0.10 (0.0039 in.)
28	1.1024	0.10
30	1.1811	0.10
32	1.2598	0.10
35	1.3780	0.10
38	1.4961	0.10
40	1.5748	0.10
45	1.7717	0.10
50	1.9685	0.10
55	2.1654	0.13 (0.0051 in.)
60	2.3622	0.13
65	2.5591	0.13
70	2.7559	0.13
75	2.9528	0.13
80	3.1496	0.13
90	3.5433	0.13
100	3.9370	0.13
110	4.3307	0.15 (0.0059 in.)
125	4.9213	0.15
140	5.5118	0.18 (0.0071 in.)
160	6.2992	0.18

NOTE. Inch equivalents are given for information only. For the purposes of this table, the metric dimensions are to be regarded as standard.

As altered
Feb., 1958

The tolerances given in this table are those acceptable for most uses. For any special application covered by a British Standard the tolerances given in that Standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.

TABLE 10. BRITISH STANDARD BRIGHT STEEL BARS FOR THE PRODUCTION OF MACHINED PARTS

SQUARE—INCH SIZES
 All tolerances + 0.000 in.

Width	Tolerance (minus)
in.	in.
below 1/4	0.002
1/4 to 7/16	0.003
1/2	0.003
5/8	0.004
3/4	0.004
7/8	0.004
1	0.004
1 1/8	0.004
1 1/4	0.004
1 1/2	0.004
1 3/4	0.005
2	0.005
2 1/4	0.005
2 1/2	0.005
2 3/4	0.005
3	0.005
3 1/4	0.006
3 1/2	0.006
3 3/4	0.006
4	0.006

NOTE. The tolerances given in this table are those acceptable for most uses.

For any special application covered by a British Standard the tolerances given in that Standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.

As altered
Feb., 1958

TABLE 11. BRITISH STANDARD BRIGHT STEEL BARS FOR THE PRODUCTION OF MACHINED PARTS
SQUARE—METRIC SIZES
All tolerances + 0.00 mm.

Width		Tolerance (minus)
mm.	in. (see note)	mm.
13	0.5118	0.10 (0.0039 in.)
14	0.5512	0.10
15	0.5906	0.10
16	0.6299	0.10
17	0.6693	0.10
18	0.7087	0.10
19	0.7480	0.10
20	0.7874	0.10
22	0.8661	0.10
24	0.9449	0.13 (0.0051 in.)
25	0.9843	0.13
27	1.0630	0.13
30	1.1811	0.13
32	1.2598	0.13
35	1.3780	0.13
36	1.4173	0.13
40	1.5748	0.13
41	1.6142	0.13
45	1.7717	0.13
46	1.8110	0.13
50	1.9685	0.13
55	2.1654	0.15 (0.0059 in.)
60	2.3622	0.15
65	2.5591	0.15
70	2.7559	0.15
75	2.9528	0.15
80	3.1496	Not specified

NOTE. Inch equivalents are given for information only. For the purposes of this table, the metric dimensions are to be regarded as standard.

The tolerances given in this table are those acceptable for most uses.

For any special application covered by a British Standard the tolerances given in that Standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.

As altered Feb., 1958

TABLE 12. BRITISH STANDARD BRIGHT STEEL BARS FOR THE PRODUCTION OF MACHINED PARTS
HEXAGON—INCH SIZES
All tolerances + 0.000 in.

Decimal sizes	Tolerance (minus)	Fractional sizes	Tolerance (minus)
in. across flats	in.	in. across flats	in.
below 0.248	0.002	below ¼	0.002
0.248	0.003	¼ to ⅜	0.003
0.282	0.003	⅜	0.003
0.324	0.003	⅝	0.004
0.365	0.003	¾	0.004
0.413	0.003	1 ¼	0.004
0.445	0.003	¾	0.004
0.525	0.003	1 ⅜	0.004
0.600	0.004	¾	0.004
0.710	0.004	1 ½	0.005
0.820	0.004	1	0.005
0.920	0.004	1 ¼	0.005
1.010	0.005	1 ½	0.005
1.100	0.005	1 ¾	0.005
1.200	0.005	1 ⅝	0.005
1.300	0.005	1 ¾	0.005
1.390	0.005	1 ¾	0.005
1.480	0.005	1 ¾	0.005
1.575	0.005	1 ¾	0.005
1.670	0.005	1 ¾	0.005
1.860	0.005	1 ¾	0.005
2.050	0.005	1 ¾	0.005
2.220	0.006	2	0.005
2.410	0.006	2 ¼	0.006
2.580	0.006	2 ⅝	0.006
2.760	0.006	2 ¾	0.006
3.018	0.006	2 ¾	0.006
3.150	0.006	2 ¾	0.006
3.340	0.006	3	0.006
3.550	0.010	3 ¼	0.006

NOTE. The tolerances given in this table are those acceptable for most uses.

For any special application covered by a British Standard the tolerances given in that Standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.

As altered Feb., 1963

As altered Feb., 1958

TABLE 13. BRITISH STANDARD BRIGHT STEEL BARS FOR THE
PRODUCTION OF MACHINED PARTS

HEXAGON—METRIC SIZES
All tolerances + 0.00 mm.

Size		Tolerance (minus)
mm across flats	in. (see note)	mm
12	0.4724	0.08 (0.00315 in.)
14	0.5512	0.10 (0.0039 in.)
17	0.6693	0.10
19	0.7480	0.10
22	0.8661	0.10
24	0.9449	0.13 (0.0051 in.)
27	1.0630	0.13
30	1.1811	0.13
32	1.2598	0.13
36	1.4173	0.13
41	1.6142	0.13
46	1.8110	0.13
50	1.9685	0.13
55	2.1654	0.15 (0.0059 in.)
60	2.3622	0.15
65	2.5591	0.15
70	2.7559	0.15
75	2.9528	0.15
80	3.1496	0.15

NOTE. Inch equivalents are given for information only. For the purposes of this table, the metric dimensions are regarded as standard.

The tolerances given in this table are those acceptable for most uses.

For any special application covered by a British Standard the tolerances given in that Standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.

As altered
Feb., 1958

APPENDIX C

DIMENSIONAL REQUIREMENTS FOR HOT ROLLED
LAMINATED SPRING PLATES

Laminated spring plates shall comply with the following dimensional requirements:—

The sections for the steels for laminated springs shall be of the dimensions given in Table 14.

Both surfaces of the spring plate shall be concave transversely, but the radius of curvature shall be such that in a 2½ inch blade or wider the thickness at the centre shall not be less than at the edge by more than 0.015 inch.

The margins of manufacture shall be as follows:—

On width ±0.6 per cent with a minimum of ±0.010 inch.
On thickness } with a minimum of ±0.005 inch.
+2 per cent
-1.5 per cent

TABLE 14. STANDARD SECTIONS FOR STEELS FOR LAMINATED SPRINGS

Width	Thickness	Width	Thickness
in.	in.	in.	in.
1	1/8	2 1/2	1/4
1	9/32	2 1/2	9/32
1	5/16	2 1/2	5/16
1 1/4	1/8	2 1/2	3/8
1 1/4	9/32	2 1/2	7/16
1 1/4	5/16	3	9/32
1 1/4	3/16	3	5/16
1 1/4	7/32	3	3/8
1 1/4	1/4	3	7/16
1 1/4	5/32	3	1/2
1 1/2	5/32	3 1/2	9/16
1 1/2	3/16	3 1/2	3/8
1 1/2	7/32	3 1/2	7/16
1 1/2	1/4	3 1/2	1/2
1 1/2	9/32	4	3/8
1 1/2	5/16	4	7/16
1 1/2	3/8	4	1/2
1 1/2	9/32	4	9/8
1 1/2	5/16	4	5/8
2	3/16	4 1/2	7/8
2	7/32	4 1/2	1/2
2	1/4	4 1/2	3/8
2	9/32		
2	5/16		
2	3/8	5	1/2
		5	9/8
2 1/4	3/16		
2 1/4	7/32		
2 1/4	1/4		
2 1/4	9/32		
2 1/4	5/16		
2 1/4	3/8		

APPENDIX D

DIMENSIONS OF BRITISH STANDARD TEST PIECES
TEST PIECE C (0.564 IN. DIA.) AND SMALLER SUBSIDIARY
STANDARD ROUND TENSILE TEST PIECES*

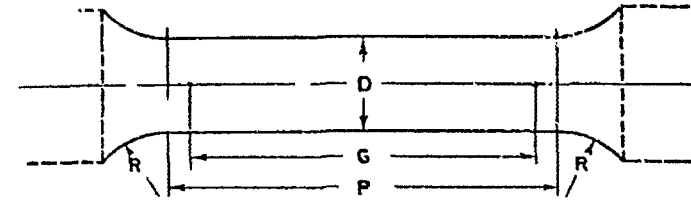


Fig. 1. Subsidiary standard round test pieces

Cross-sectional area $A = \frac{\pi D^2}{4}$.

Gauge length $G = 4\sqrt{A} = 3.54 D$.

Parallel length $P = \frac{9}{8} G$ minimum $\pm 3.98 D$ minimum.

Radius R at shoulder for wrought metals = $\frac{G}{4}$ minimum.
(0.88 D minimum.)

Diameter D	Cross-sectional area A	Gauge length G	Parallel length P (minimum)	Radius at shoulder R (minimum)
in.	sq. in.	in.	in.	n
0.564	0.2498	2.00	2.25	0.50
0.424	0.1412	1.50	1.69	0.37
0.399	0.1250	1.41	1.58	0.35
0.357	0.1000	1.26	1.42	0.31
0.282	0.0625	1.00	1.12	0.25
0.226	0.0401	0.80	0.90	0.20
0.159	0.0199	0.56	0.63	0.14
0.125	0.0123	0.44	0.50	0.11

* Abstracted from B.S. 18 'Tensile testing of metals'

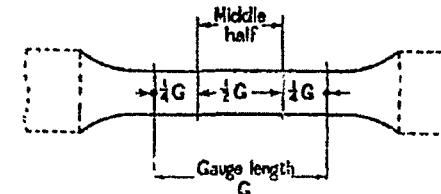


Fig. 2. Sketch illustrating middle half of gauge length

STANDARD TEST PIECES FOR NOTCHED BAR IMPACT TESTS

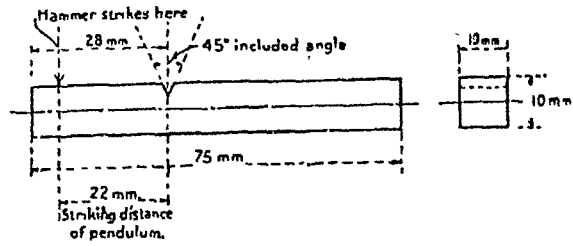


Fig. 3. Square test piece with single notch

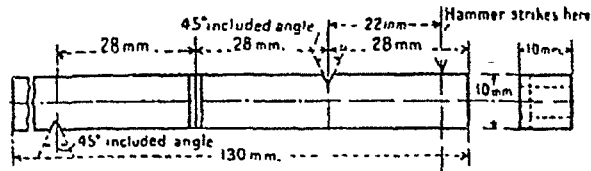


Fig. 4. Alternative square test piece providing for 3 notches

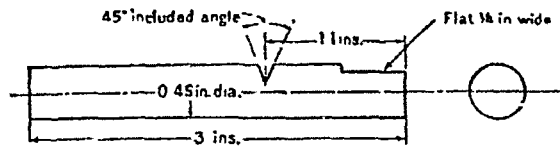


Fig. 5. Round test piece with single notch

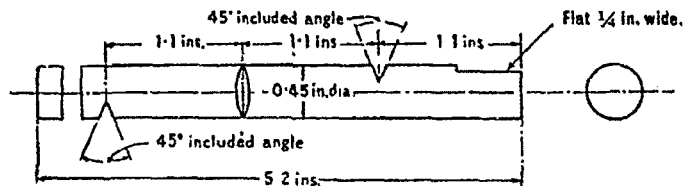


Fig. 6. Alternative round test piece providing for 3 notches

STANDARD NOTCHES FOR NOTCHED BAR IMPACT TEST PIECES

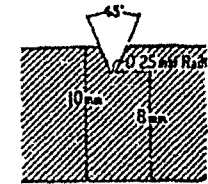


Fig. 7. Enlarged view of notch for square test piece

A gauge having an 8 mm. opening shall pass over the test piece at the bottom of the notch.

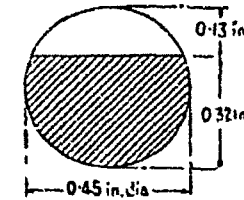


Fig. 8. Enlarged view of notch for round test piece

A gauge having a 0.320 inch opening shall pass over the test piece at the bottom of the notch.

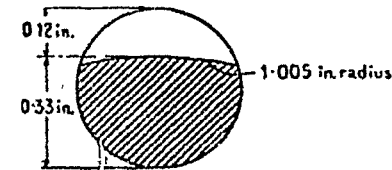


Fig. 9. Alternative notch for round test piece

A gauge having a 0.330 inch opening shall pass over the test piece at the bottom of the notch.

NOTE. This notch shall be cut by mounting the specimen in an eccentric mandrel, the centre of the specimen being 0.9 inch from the centre of the mandrel.

APPENDIX E
INFORMATION ON 'RULING SECTION' AND
'EQUIVALENT SECTION'

The object of this appendix is to draw attention to the influence of size and shape in determining the mechanical properties produced in steel by heat treatment. The size and shape are the main factors determining the rate of cooling during treatment and the rate of cooling, taken in conjunction with the composition of the steel, determines the mechanical properties obtained. It is this interrelation of final properties and size and shape which is commonly referred to as 'mass effect'.

In selecting a steel, one of the most important considerations is that its composition should allow the desired mechanical properties to be developed by the heat treatment to be used in the size and shape at the heat treatment stage.

The term 'ruling section' is used in many British Standards, and the 'limiting ruling section' is always expressed as the maximum diameter of round bar in which the specified properties may be produced in the steel concerned by the heat treatment specified. Since many parts at the time of heat treatment do not even approximate in shape to round bar, it is necessary to have some means of relating the rates of cooling of other shapes to their 'equivalent sections' of round bar. The diameters of round bars, the centres of which would cool through a given temperature range at the same rate as the centres of rectangular or square sections bars of different sizes, have been calculated by the methods described in the first report of the Alloy Steel Research Committee, Iron and Steel Institute Special Report No. 14, 1936, page 149. For the purpose of the calculations, only the size and shape have been considered and the other factors such as specific heat, thermal conductivity and phase changes have been ignored. The curves and tables which follow should be used, therefore, only for comparing sections of the same steel and not for comparing steels of different types.

NOTE The calculations were made for cooling in air or oil at 20°C through the range 820°C to 300°C but the results are applicable where the ratio of fall in temperature of the centre to the fall in temperature of the surface is the same as for the conditions assumed, i.e. where

$$\frac{\text{Temperature at centre of piece} - \text{Temperature of oil (air)}}{\text{Initial temperature of piece} - \text{Temperature of oil (air)}} = 0.35$$

Moreover, the results apply to any range of temperature where the time of cooling is such that only one term is required in the expansions of the formulae given in the reference above.

'h' is taken to be 0.8 for oil quenching and 0.03 for air cooling, where:
'h' represents the quantity of heat transferred per unit area of surface per unit time per degree of temperature difference between the body and the surrounding medium, divided by the thermal conductivity of the material, all the quantities being expressed in the C.G.S. system and the temperature in degrees Centigrade.

The results of the calculations are given here in the form of tables for converting the sizes of plates or rectangular sections into equivalent sizes of rounds for oil quenching and for air cooling respectively. For most purposes the tables giving direct conversion into the 'equivalent round' are easier to use but graphs are also provided from which can be read a factor which, multiplied by the thickness of a rectangular section, will give the 'equivalent round.' As an example of how the tables should be used, the centre of a square section of 1½ in. sides will, when oil quenched, cool at the same rate as a round section of 1.60 in. diameter, while the 'equivalent round' corresponding to a rectangular section of 1½ in by 3 in. will, for oil quenching, be 2.10 in. diameter.

Results sufficiently close for many practical purposes may be obtained by noting that over certain ranges of sizes an approximate conversion factor may be used. Thus for rectangular sections where the breadth is 1½ times the thickness the conversion factor varies little for thicknesses between 1 in and 4 in. and, for oil quenching, multiplying the thickness by 1.28 gives a close conversion to the equivalent diameter of round bar.

Sections other than rounds or rectangles are difficult to treat mathematically but close approximations may usually be obtained. Octagonal and hexagonal parts are intermediate in cooling rate between round and square the order of increasing time of cooling being round, octagonal, hexagonal, square. The conversion factor (based on dimensions across flats) for hexagons and octagons will lie between 1.0 and 1.085 with oil quenching and still closer with air cooling so that no serious errors can arise. Oval sections with major axis 'a' and minor axis 'b' will cool more slowly than a round bar of diameter 'b' but faster than a rectangle 'a' × 'b'. More accurate results may be obtained by converting the oval section to an equivalent rectangular section of sides 'A' and 'B' such that the area is the same as the oval section and A : B as a : b.

Careful consideration has to be given to cases where the section varies along the length of the part in order to decide which section is to be looked on as the controlling section at the time of heat treatment. The importance or otherwise of obtaining the full mechanical properties at the section should be considered. In the case of parallel shafts having flanges, collars, or other enlarged portions, the length of such enlarged portions in relation to the diameter should be taken into account. If the ratio of length to diameter is great then the diameter of such a portion will be the determining dimension, but if the ratio is small the portion may be viewed as a disc or plate in which the thickness is the determining feature. For intermediate cases the distance from the centre of the enlarged section to the nearest point of the external surface will in general decide the ruling dimension.

TABLE 15. CONVERSION OF RECTANGULAR SECTIONS AND PLATES INTO EQUIVALENT ROUNDS.

OIL QUENCHING

B = breadth of section. T = thickness of section.

$\frac{B}{T}$ for plate = ∞

T	Diameter of equivalent round in inches to nearest 0.05 inch					
	$\frac{B}{T}$					
	1	1½	2	2½	3	∞
in.						
½	0.50	0.65	0.70	0.75	0.80	0.85
1	1.05	1.30	1.40	1.50	1.55	1.65
1½	1.60	1.90	2.10	2.25	2.30	2.40
2	2.15	2.55	2.80	2.95	3.05	3.10
2½	2.70	3.20	3.50	3.70	3.75	3.85
3	3.25	3.85	4.20	4.40	4.50	4.55
3½	3.80	4.50	4.90	5.10	5.20	5.25
4	4.35	5.10	5.60	5.80	5.90	6.00
4½	4.90	5.75	X	X	X	X
5	5.45	X	X	X	X	X
5½	6.00	X	X	X	X	X

X = Over 6 in.

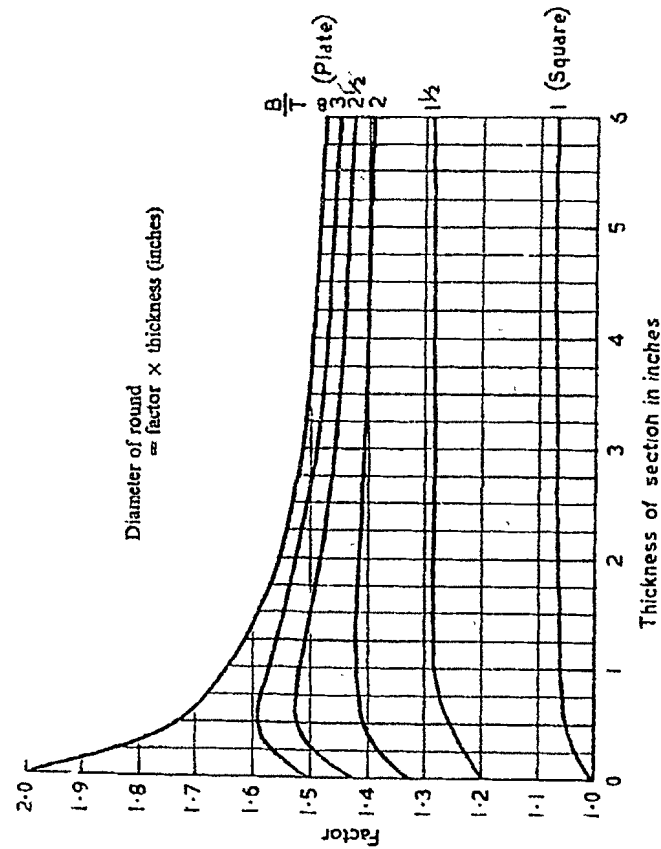


Fig. 10. Equivalent rounds for rectangular sections and plates. Oil quenching

TABLE 16. CONVERSION OF RECTANGULAR SECTIONS AND PLATES INTO EQUIVALENT ROUNDS.

AIR COOLING

B = breadth of section. T = thickness of section

$$\frac{B}{T} \text{ for plate} = \infty$$

T	Diameter of equivalent round in inches to nearest 0.05 inch							
	$\frac{B}{T}$							
	1	1½	2	2½	3	3½	4	∞
in.								
½	0.50	0.60	0.65	0.70	0.75	0.80	0.80	1.00
1	1.00	1.20	1.35	1.45	1.55	1.60	1.65	1.95
1½	1.50	1.85	2.05	2.20	2.30	2.40	2.45	2.95
2	2.00	2.45	2.70	2.90	3.10	3.20	3.30	3.85
2½	2.55	3.05	3.40	3.65	3.85	4.05	4.15	4.80
3	3.05	3.65	4.10	4.40	4.65	4.85	5.00	5.70
3½	3.55	4.30	4.80	5.15	5.40	5.65	5.85	X
4	4.10	4.90	5.50	5.90	X	X	X	X
4½	4.60	5.55	X	X	X	X	X	X
5	5.10	X	X	X	X	X	X	X
5½	5.65	X	X	X	X	X	X	X

X = Over 6 in

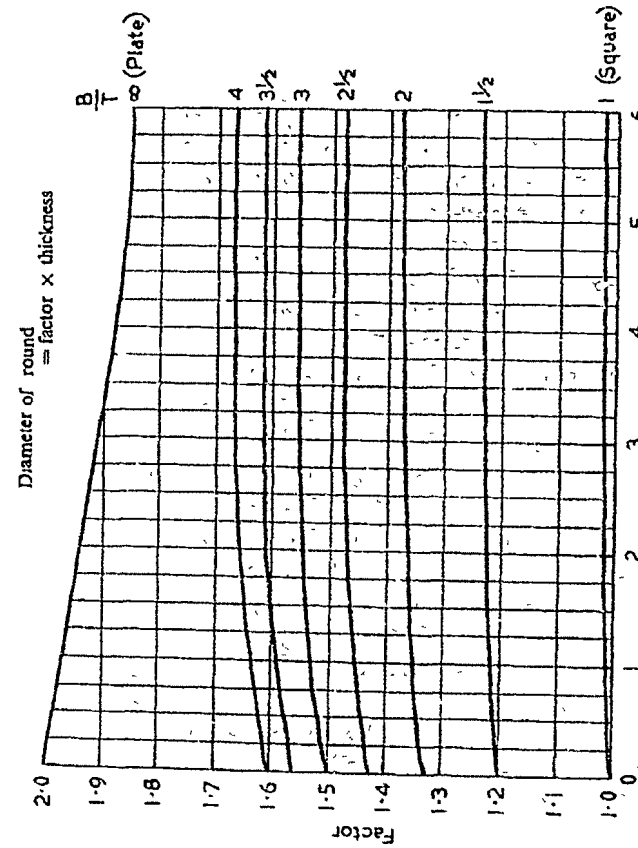


Fig. 11. Equivalent rounds for rectangular sections and plates. Air cooling

BRITISH STANDARDS INSTITUTION

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PD 2971

Amendment No. 2, published 25 February, 1958

to B.S. 970 : 1955

Wrought steels (bar, billets and forgings)

Revision

Appendix B. Tables 8 to 13. Add the following note at the foot of each table :—

** NOTE. The tolerances given in this table are those acceptable for most uses. For any special application covered by a British Standard the tolerances given in that standard should apply. If a special application is not covered by a British Standard the tolerances may be as agreed between the purchaser and supplier.**

P D. 2127

Amendment No. 1, published 23 February, 1955

to B.S. 970 : 1955

Wrought steels (bars, billets and forgings)

Corrigenda

Page 34. Top left hand corner. Delete heading 'En 4A' and substitute 'En 1A'.

Page 47. Top right hand corner. Delete heading 'En 1A' and substitute 'En 4A'.

PD. 3092

Amendment No. 3, published 25 June 1958

to B.S. 970 : 1955

Wrought steels (bars, billets and forgings)

Revision

Pages 164 and 165: En 56A, 56B, 56C, 56D. Add at top of pages 'En 56.'

Page 164: Delete first paragraph and substitute the following.

En 56. The range of composition of En 56 which is sub-divided into Grades En 56A, En 56B, En 56C, En 56D is suitable for tensile ranges of 35/45 (P), 45/55 (R), 50/60 (S), 55/65 (T) and 75/85 (X) tons/sq in. The purchaser should state on the order the condition P, R, S, T, or X for which the material is ultimately required and the ruling section at the time of heat treatment. The selection of En 56A, En 56B, En 56C or En 56D will be governed by the ruling section and the tensile range required, and unless otherwise agreed will be at the discretion of the steel maker.

PD 4814

**Amendment No 4, published 27 February, 1963
to B.S. 970 : 1955**

**Wrought steels in the form of bars, billets and forgings
up to 6 in. ruling section for automobile and
general engineering purposes**

Revision

PART 1. GENERAL CLAUSES

Clause 1. General requirements. Add the following paragraph:

' In order to assist the supplier, the purchaser is recommended to indicate in the enquiry and order the purpose for which the material is to be used. A drawing of the part in question is useful '.

Clause 3. Freedom from defects. Delete the text and substitute:

' The steel shall be free from piping, harmful segregation and other defects and in addition:

a. Billets and bars for forgings shall be rough machined, chipped, ground or otherwise prepared to remove surface defects which might produce defects in the bars, forgings or drop forgings made therefrom;

b. Billets for re-rolling and bars for other than forging purposes shall be free from harmful surface defects;

c. Bars for machining shall be commercially straight,

d. Forgings and drop forgings shall be finished in a workmanlike manner and shall be free from flaws and surface defects;

e. Case hardening steels shall be capable of being carburised and heat-treated to give a satisfactory uniform surface hardness '.

PART 2. SPECIFIC REQUIREMENTS

En1A. Free cutting steel for machining. Delete the footnote regarding parts which are to be case hardened and substitute:

' This steel is supplied as a free cutting steel for machining. It is not supplied for case hardening and this requirement does not form part of the specification. For guidance only, a core strength of approximately 28 tons/sq. in. should be expected if this steel is heat treated in accordance with the requirements of En32A '.

En1B. Free cutting steel bars for machining (higher sulphur). Delete the footnote regarding parts which are to be case hardened and substitute:

' This steel is supplied as a free cutting steel for machining. It is not supplied for case hardening, and this requirement does not form part of the specification. For guidance only, a core strength of approximately 28 tons/sq. in. should be expected if this steel is heat treated in accordance with the requirements of En32A '.

En3A, 3C. '20' carbon steel (hot rolled or normalised). In the first sentence, delete ' in the normalised condition '.

Condition of material on delivery. Amend Sub-clause c (iv) to read: 'Bright drawn finished-normalised '.

En6, 6K, 6A. Bright carbon steel. *Mechanical properties.* Delete properties for $\frac{3}{4}$ in size or less (diameter or width across flats) and substitute:

Tensile strength, tons/sq. in.	
min.	35
max.	45
Elongation, per cent, min.	12
Izod impact value, ft lb, min	20

En7. Semi-free cutting carbon steel. *Chemical composition.* Delete minimum percentage manganese content and substitute: '1.0'.

En8. '40' carbon steel. *Condition of material on delivery.* Delete Sub-clause d and substitute:

'Bright bars shall be delivered in accordance with the tables '.

Mechanical properties. Delete table entitled 'Normalised or hardened and tempered ' and substitute:

NGC 1 FINALLY NORMALISED OR HARDENED AND TEMPERED (WITHOUT GRAIN SIZE CONTROL)

Property	Condition		
	Normalised	Hardened and tempered	
		Q	R
Limiting ruling section, in.	6	2½	¾
Tensile strength, tons/sq. in., min	35	40	45
Yield stress, tons/sq. in., min	18	28	32
Elongation, per cent, min	20	22	20
Izod impact value, ft. lb., min.	—	10	10
Brinell hardness number	152 207	179 229	201 255

NGC 2. NORMALISED OR HARDENED AND TEMPERED AND FINALLY BRIGHT DRAWN (WITHOUT GRAIN SIZE CONTROL)

Property	Condition		
	Normalised	Hardened and tempered	
		Q	R
Limiting ruling section, in.	6	2½	¾
Tensile strength, tons/sq. in., min.	35	40	45
Yield stress, tons/sq. in., min.	18	28	32
Elongation, per cent, min	17	17	17
Brinell hardness number	152 207	179 229	201 255

GC 1. CONTROLLED GRAIN* FINALLY NORMALISED OR HARDENED AND TEMPERED

Property	Condition				
	Normalised		Hardened and tempered		
			Q	R	
Limiting ruling section, in.	4	6	2½	¾	¾
Tensile strength, tons/sq. in., min.	35	35	40	45	45
Yield stress, tons/sq. in., min	18	18	28	32	32
Elongation, per cent, min.	20	20	22	20	20
Izod impact value, ft. lb., min	20	15	25	40	25
Brinell hardness number	152 207	152 207	179 229	201 255	201 255

* Controlled grain steel to this specification shall possess a McQuaid-Ehn grain size of 5-8.

GC 2. CONTROLLED GRAIN* NORMALISED OR HARDENED AND TEMPERED AND FINALLY BRIGHT DRAWN

Property	Condition			
	Normalised	Hardened and tempered		
		Q	R	
Limiting ruling section, in.	6	1½	2½	¾
Tensile strength, tons/sq. in., min	35	40	40	45
Yield stress, tons/sq. in., min	18	28	28	32
Elongation, per cent, min	17	17	17	17
Izod impact value, ft. lb., min	†	25	15	25
Brinell hardness number	152 207	179 229	179 229	201 255

* Controlled grain steel to this specification shall possess a McQuaid-Ehn grain size of 5-8.

† An Izod impact value of 10 ft lb minimum is specified where the carbon content does not exceed 0.40 per cent.

Delete title of Table 'COLD DRAWN' and substitute

'COLD DRAWN (FOLLOWING HOT ROLLING, i.e. NOT HARDENED AND TEMPERED)

En8A, 8B, 8C, 8D, 8E. '40' carbon steel.

En8AM, 8BM, 8CM, 8DM. '40' carbon steel—free cutting.

En12A, 12B, 12C. 1 per cent nickel steel.

In the second line of the paragraph immediately above tables of chemical compositions delete 'only'. Add at the end of the paragraph. 'but they may be negotiated between the purchaser and the supplier'.

En8M, 8AM, 8BM, 8CM, 8DM. '40' carbon steel—free cutting. *Chemical composition.* Delete minimum percentage manganese content and substitute '1.0'.

En14A. Carbon-manganese steel. *Mechanical properties, Table.* In the normalised condition, insert an Izod impact value of

'15'

and insert a footnote below the table to read:

' * 30 for controlled grain steel '.

En14B. Carbon-manganese steel. *Mechanical properties, Table.* In the normalised condition, insert an Izod impact value of

'15'

and insert a footnote below the table to read:

' * 30 for controlled grain steel '.

Table 12. British Standard bright steel bars for the production of machined parts. Add the following:

Decimal sizes	Tolerance (minus)
3-560	0 010

AMD 415

Amendment Slip No. 6, published 12 February, 1970
to B.S. 970 : 1955

Wrought steels in the form of bars, billets and forgings
up to 6 in. ruling section for automobile and
general engineering purposes

NOTE. This amendment is necessary due to the publication of Part 4 of the revision of B.S. 970 covering the stainless, heat resisting and valve steels

Revised text

Foreword

Add the following additional paragraph to the end of the Foreword:

'For stainless, heat resisting and valve steels refer to BS 970 : Part 4 : 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 4, 'Stainless heat resisting and valve steels'.'

Part 2. Specific requirements

Delete the entries in the specific requirements for the following steels:

En 51—En 52—En 53—En 54, 54A—En 55—En 56, 56A, 56B, 56C, 56D—
En 56AM, 56BM, 56CM, 56DM—En 57—En 58A, 58B, 58C, 58D, 58E, 58F,
58G, 58H, 58J, 58M—En 59—En 60, 61.

AMD 157

Amendment Slip No. 5, published 9 December, 1968
to B.S. 970 : 1955

Wrought steels in the form of bars, billets and
forgings up to 6in. ruling section for automobile and
general engineering purposes

Correction

Part 2. Specific requirements

En 8M, 8AM, 8BM, 8CM, 8DM. In the table giving chemical composition for the steels En 8AM, 8BM, 8CM, 8DM, which may be ordered for special applications, delete the minimum manganese content of '0.90%' and substitute '1.0%' in each case.

NOTE This amendment only applies to certain reprinted copies of BS 970 in which Amendment No. 4, PD 4814, was not correctly incorporated.

AMD 553

Amendment Slip No. 7, published 4 September, 1970
to B.S. 970 : 1955

Wrought steels in the form of bars, billets and forgings
up to 6 in. ruling section for automobile and
general engineering purposes

NOTE. This amendment is necessary due to the publication of Part 2 of the revision of B.S. 970 covering the direct hardening alloy steels including alloy steels capable of surface hardening by nitriding.

Revised text

Foreword

Add the following additional sentence to the beginning of last paragraph of the Foreword:

'For direct hardening alloy steels including alloy steels capable of surface hardening by nitriding refer to B.S. 970 : Part 2 : 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 2, 'Direct hardening alloy steels including alloy steels capable of surface hardening by nitriding'.'

Part 1. General clauses

Table 3. Tensile strengths of hot rolled or normalised bars, billets, forgings and drop forgings—other than free-cutting steels. Delete the entry related to En 12.

Table 4. Tensile strengths of hardened and tempered bars, billets, forgings and drop forgings. Delete all entries after and including those for En 12 on pages 24 to 29 inclusive.

Table 5. Tensile strengths of hardened and tempered bars, billets, forgings and drop forgings—nitriding steels. Delete this table entirely.

Part 2. Specific requirements

Delete the entries in the specific requirements for the following steels:

En 10—En 11—En 12, 12A, 12B, 12C—En 13—En 16, 16A, 16B, 16C, 16D—En 16M—En 17—En 18, 18A, 18B, 18C, 18D—En 19—En 19A, 19B, 19C—En 20A, 20B—En 21, 21A—En 22—En 23—En 24—En 25—En 26—En 27—En 28—En 29A, 29B—En 30A, 30B—En 31—En 40A, 40B—En 40C—En 41A, 41B—En 100, 100A, 100E, 100C, 100D, 100E—En 110—En 111, 111A—En 160, 160A.

AMD 757

Amendment Slip No. 8, published 30 July, 1971

to B.S. 970 : 1955

**Wrought steels in the form of bars, billets and
forgings up to 6 in. ruling section for automobile
and general engineering purposes**

NOTE This Amendment is necessary due to the publication of Part 3 of the revision of B.S. 970 presently covering alloy steels for case hardening.

Revised text

Foreword (as amended by Amendments Nos. 6 and 7)

Delete the sixth paragraph which commences 'The case hardening steels

Delete the final paragraph (for certain reprinted copies of the standard it will be necessary to delete the last two paragraphs) commencing 'For direct hardening alloy steels', and substitute the following:

'For direct hardening alloy steels including alloy steels capable of surface hardening by nitriding refer to B.S. 970: Part 2: 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 2, 'Direct hardening alloy steels including alloy steels capable of surface hardening by nitriding'. For alloy steels for case hardening refer to B.S. 970: Part 3: 1971, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 3, 'Steels for case hardening'. For stainless, heat resisting and valve steels refer to B.S. 970: Part 4: 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 4, 'Stainless, heat resisting and valve steels'.'

Part 1. General clauses

Clause 7. Provision of material for testing

Delete '(d) Casehardening steels' and substitute (d) *Carbon and carbon manganese case hardening steels*

Table 6 Tensile strengths of the cores of case-hardened steels. Delete the entries related to: En37, En33, En34, En351, En361, En35, En36A, En325, En352, En362, En36B, En36C, En38, En353, En363, En354, En39A, En39B, En355.

Part 2. Specific requirements

Delete the entries in the specific requirements for the following steels: En33 – En34 – En35, 35A, 35B – En36A, 36B, 36C – En37 – En38 – En39A, 39B – En206 – En207 – En325 – En351 – En352 – En353 – En354 – En355 – En361 – En362 – En363.

Price 10p

AMD 842

**Amendment Slip No. 9, published 14 February, 1972
to B.S. 970:1955**

**Wrought steels in the form of bars, billets and forgings
up to 6 in. ruling section for automobile and
general engineering purposes**

NOTE. This amendment is necessary due to the publication of Part 1 of the revision of B.S. 970 covering carbon and carbon manganese steels including free-cutting steels.

Revised text

Foreword. Delete the text of the existing Foreword entirely and substitute the following:

'This 1955 edition of B.S. 970 is presently being revised in five separate parts. So far four parts of this revision have been published as follows:

B.S. 970 : Part 1 : 1972, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 1, 'Carbon and carbon manganese steels including free cutting steels'.

B.S. 970 : Part 2 : 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 2, 'Direct hardening alloy steels including alloy steels capable of surface hardening by nitriding'.

B.S. 970 : Part 3 : 1971, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 3, 'Steels for case hardening'. (Presently covering alloy steels for case hardening only).

B.S. 970 : Part 4 : 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 4, 'Stainless, heat resistant and valve steels'.

Amendments Nos. 6, 7, 8 and 9 have been published to delete, from this edition of B.S. 970, those steel types which are now covered by the above four parts of the revision. It is also additionally intended that requirements for carbon and carbon manganese steels for case hardening will be added to Part 3, by amendment action, and that requirements for steels for the manufacture of hot formed and heat treated springs will be published as Part 5 of the revision. Thus, when these are published this 1955 edition will be withdrawn. Until then it is necessary for it to continue in existence so that requirements for carbon and carbon manganese steels for case hardening and requirements for steels for the manufacture of hot formed and heat treated springs will continue to be covered.

It should also be noted that, as a result of these changes, certain requirements given in the General Clauses of this standard may no longer continue to apply. This will be apparent from each of the specific requirements for the steels remaining in Part 2 of B.S. 970 : 1955.'

Price 10p

Gr 0

Part 1. General clauses

Insert the following Note between the main heading 'Part 1. General clauses' and the first paragraph which commences 'Ruling section. In the selection '.

'NOTE. Due to the publication of Parts 1, 2, 3 and 4 of the revision to this standard and the deletion from this standard of the steels covered by these parts, certain of the requirements given in these general clauses may no longer continue to apply (see also the Foreword).'

Table 1. Tensile strengths of cold drawn bars—other than free-cutting steels.

Delete this table entirely.

Table 2. Tensile strengths of cold drawn free-cutting bars. Delete this table entirely.

Table 3. Tensile strengths of hot rolled or normalised bars, billets, forgings and drop forgings—other than free-cutting steels (as amended by Amendment No. 7). Delete this table entirely.

Table 4. Tensile strengths of hardened and tempered bars, billets, forgings and drop forgings (as amended by Amendment No. 7). Delete this table entirely.

Part 2. Specific requirements

Delete the entries in the specific requirements for the following steels.

En 1A-En 1B-En 2-En 2A, 2A/1, 2B, 2C, 2D-En 2E-En 3, En 3A, 3C-En 3B-En 3D-En 4-En 4A-En 5, 5K, 5A, 5B, 5C-En 5D-En 6, 6K, 6A-En 7-En 7A-En 8, 8A, 8B, 8C, 8D, 8E-En 8K-En 8M, 8AM, 8BM, 8CM, 8DM-En 9, 9K-En 14A-En 14 A/1-En 14B-En 15-En 15A-En 15AM-En 15B-En 43A, 43B, 43C, 43D, 43E.

AMD 981

**Amendment Slip No. 10, published 9 June, 1972
to B.S. 970:1955**

**Wrought steels in the form of bars, billets and forgings
up to 6in. ruling section for automobile and
general engineering purposes**

NOTE. This amendment is necessary due to the publication of Part 5 of the revision of B.S. 970 covering carbon and alloy steels for the manufacture of hot formed springs.

Revised text

Foreword. Delete the text of the existing Foreword entirely and substitute the following:

'This 1955 edition of B.S. 970 has been revised in five separate parts as follows:

B.S. 970 Part 1 : 1971, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 1, 'Carbon and carbon manganese steels including free-cutting steels'

B.S. 970 Part 2 : 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 2, 'Direct hardening alloy steels including alloy steels capable of surface hardening by nitriding'.

B.S. 970 : Part 3 : 1971, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 3, 'Steels for case hardening'. (Presently covering alloy steels for case hardening only)

B.S. 970 : Part 4 : 1970, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 4, 'Stainless, heat resistant and valve steels'.

B.S. 970 : Part 5 : 1972, 'Wrought steels in the form of blooms, billets, bars and forgings', Part 5, 'Carbon and alloy steels for the manufacture of hot formed springs'

Amendments Nos. 6, 7, 8, 9 and 10 have been published to delete, from this edition of B.S. 970, those steel types which are now covered by the above five parts of the revision and it is additionally intended that requirements for carbon and carbon manganese steels for case hardening will be added to Part 3 of the revision, by amendment action. Thus, when this is published, the revision of this 1955 edition will be complete and it will be withdrawn. Until then, it is necessary for it to continue in existence so that requirements for carbon and carbon manganese steels for case hardening will continue to be covered.

Gr 0

It should also be noted that, as a result of these changes, certain requirements given in the *General Clauses* of this standard may no longer continue to apply. This will be apparent from each of the specific requirements for the steels remaining in Part 2 of B.S. 970 : 1955.'

Part 1. General clauses (as amended by Amendment No. 9)

Delete the Note (as inserted according to Amendment No. 9) under the main heading 'Part 1. General clauses' and substitute the following:

'NOTE Due to the publication of Parts 1, 2, 3, 4 and 5 of the revision to this standard and the deletion from this standard of the steels covered by these parts, certain of the requirements given in these general clauses may no longer continue to apply (see also the Foreword).'

Table 7. Summary of spring steel bars. Delete this table entirely.

Part 2. Specific requirements

Delete the entries in the specific requirements for the following steels:

En 42, 42B, 42C, 42D, 42E, 42F, 42G, 42J-En 43, 43G, 43J-En 44, 44B, 44C, 44D, 44E-En 45, 45A-En 46-En 47-En 48-En 48A-En 49A, 49B, 49C, 49D-En 50.