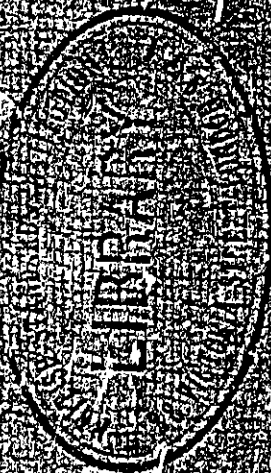


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CO-OPERATING ORGANISATIONS

The Iron and Steel Industry Committee under which this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organisations :

- *Admiralty
- Board of Trade
- Crown Agents for the Colonies
- Home Office
- *Ministry of Aircraft Production
- Ministry of Health
- *Ministry of Supply
- *Alloy Steels Association
- Association of Consulting Engineers
- British Cast Iron Research Association
- British Corporation and Register of Shipping and Aircraft
- British Electrical and Allied Manufacturers' Association
- British Engineers' Association
- *British Iron and Steel Federation
- British Ironfounders' Association
- *British Steel-Wire Industries Association
- British Steelwork Association
- Council of British Wrought Iron Association
- Federation of Civil Engineering Contractors
- Institution of Automobile Engineers
- Institute of British Foundrymen
- Institution of Automobile Engineers
- Institution of Civil Engineers
- Institution of Structural Engineers
- Iron and Steel Industrial Research Council
- Iron and Steel Institute
- Iron and Steel Trades Employers' Association
- Lloyd's Register of Shipping
- National Association of Drop-Forgers and Stampers
- National Ironfounding Employers' Association
- National Physical Laboratory
- *Railway Companies of Great Britain
- Shipbuilding Employers' Federation
- Society of British Aircraft Constructors
- Steel Castings Association—General Steel Casting

The Government departments and scientific and industrial organisations 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 :

- Bolt and Nut Manufacturers' Associations
- Bright Steel Bar Association
- Laminated Railway Spring Manufacturers' Association
- N.E. Coast Institute of Engineers and Shipbuilders
- Railway Carriage and Wagon Builders' Financiers' Parliamentary Association
- Society of Motor Manufacturers and Traders Ltd.

THIS SCHEDULE, having been approved by the Iron and Steel Industry Committee and endorsed by the chairman of the Engineering Divisional Council, was published under the authority of the General Council as a British Standard on

First published, July, 1941

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Second revision, March, 1947

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, the 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 one thousand, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 2s. 0d. post free.

This schedule requires reference to the following :

B.S. 18. Tensile testing of metals.

B.S. 131. Forms of notched bar impact test pieces.

B.S. 240. Part 1. Brinell hardness, methods and tables for.
Part 2. Hardness of steel balls for Brinell hardness testing.

B.S. 427. Tables of diamond pyramid hardness numbers.

B.S. 860. Table of approximate comparison of hardness numbers.

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

Users wishing to be kept informed of any alteration to this standard should notify Publications Sales Department of the Institution, giving the number and title of the standard.

ISE/31

BRITISH STANDARD SCHEDULE OF STEELS FOR AUTOMOBILE AND GENERAL ENGINEERING PURPOSES

FOREWORD TO THIRD ISSUE

For a number of years it had been apparent that B.S. 5005, 1924, not only did not offer the best selection of wrought steels for automobiles, but that in some quarters it had not been realised in using these specifications (particularly 5005/402) that the tests quoted could only be obtained in sections varying with the steel and the tensile strength required.

In 1940 the Technical Advisory Committee of the Special and Alloy Steels Committee of the Steel Control of the Ministry of Supply, composed of steelmakers, representatives of the Services and the British Standards Institution, under the chairmanship of the late Dr. W. H. Hatfield, F.R.S., working in consultation with important consumers, had carried out a rationalisation of specifications for special and alloy steels to meet war conditions.

In order to give effect to its recommendations, the Technical Advisory Committee prepared, at the request of the Materials Committee of the Production Executive, a new series of specifications intended to provide a comprehensive schedule of steels for general use in the engineering industry. This was issued as B.S. 970 : 1941 and an important feature of the En. specifications contained in this schedule was 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 B.S. 970 : 1941 there was issued B.S. 971 which classified the steels to be regarded as standard steels for war purposes supplied in the form of billets, bars and light forgings up to and including 6 in. ruling section. This also contained 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.

A new issue of B.S. 970 was made in 1942 and B.S. 971 was revised in 1944.

Arising from discussions between the Technical Advisory Committee and the Technical Sub-Committee of the Materials Committee of the Society of Motor Manufacturers and Traders, held in January, 1945, it was agreed that B.S. 970 should be reviewed and amplified in order to incorporate the post-war requirements of the Society of Motor Manufacturers and Traders.

This involved the inclusion of additional specifications for carbon steels and this issue differs from previous issues in the introduction of

sub-divisions 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 from material within these composition limits. The sub-divisions of the specification require more 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 composition specified.

GENERAL CLAUSES

GENERAL

1. The steels dealt with in this schedule shall comply in all respects with the requirements herein laid down, and may be subjected to both the chemical analysis and the mechanical tests, unless it is specified that only the mechanical tests will be applied. The specified ranges of chemical composition are based on cast analyses. Any subsequent analytical checks shall take into consideration the heterogeneity normal to the steel. Where mechanical tests are not a contractual section of the specification, the material shall be supplied to chemical composition only.

MANUFACTURE

2. *a. Process.* All steel shall be manufactured in accordance with the best current practice.

b. Discard. A sufficient discard shall be made from each ingot to secure reasonable freedom from piping and harmful segregation, and other defects.

c. Freedom from defects. (i) Billets and bars for forging shall be rough machined, chipped, ground or otherwise prepared so as to remove all surface defects which might produce defects in the bars, forgings or drop-forgings made therefrom.

(ii) All bars for machining shall be sound, commercially straight and free from harmful surface defects. As an alternative to a black finish, the bars may be required in the bright condition, i.e., machined, ground, bright reeled, cold drawn, cold rolled, or cold rectified as ordered.

(iii) All forgings and drop-forgings shall be finished in a workmanlike manner and shall be free from flaws and surface defects.

d. Test samples on forgings and drop-forgings. If required a prolongation shall be left on each forging or drop-forging for test purposes.

Alternatively, by agreement, representative samples from the same cast may be provided for testing for each batch of forgings or drop-forgings, heat treated together. See also clause 6.

e. Optional elements. Optional elements are included in specifications En. 23 and 38, for use at the discretion of the steelmaker in order to secure the desired mechanical properties. They are also included in specifications En. 56M, for improved machining properties, and in En. 58 and En. 58B, for increased corrosion resistance.

f. Residuals. For alloy steels in general the percentages of elements up to the following amounts shall be looked upon as incidental : nickel 0.40 per cent ; chromium 0.30 per cent ; molybdenum 0.15 per cent ; and vanadium 0.05 per cent.

For carbon steels in general 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 purposes of finishing the heat. All reasonable precautions shall be taken to prevent addition of such elements from scrap or other materials used in manufacture.

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

g. Lead bearing steels. Lead bearing steels shall only be supplied by agreement between purchaser and supplier. The lead content shall be not less than 0.15 and not more than 0.35 per cent, and the steel shall be identifiable by a distinguishing mark agreed between the purchaser and the supplier.

HEAT TREATMENT DEFINITIONS

3. a. Heat treatment. A process in which steel in the solid state is subjected to one, or more than one, temperature cycle, to confer certain desired properties.

NOTE. Heating for the sole purpose of hot working is excluded from the meaning of this definition.

b. Annealing. Heating to and holding at a suitable temperature, followed by cooling at a suitable rate, for such purposes as :

- (1) Inducing softness.
- (2) Improving machinability.
- (3) Improving cold working properties.
- (4) Obtaining a desired structure.
- (5) Removing stresses.

NOTE. When applicable, the more specific terms Sub-critical Annealing, Full Annealing, or Isothermal Annealing, should be used.

c. Full annealing. Heating to and holding at some temperature above the transformation range, followed by cooling slowly through the transformation range.

d. Sub-critical annealing. Heating to and holding at some temperature below the transformation range, followed by cooling at a suitable rate.

e. Normalising. Heating to, and, if necessary, holding at, a suitable temperature above the transformation range, followed by cooling freely, in order to modify the grain size, render the structure more uniform, and usually to improve the mechanical properties.

f. Quenching. Rapid cooling.

g. Hardening. Increasing the hardness by heat treatment. This usually implies quenching from a temperature either within or above the transformation range.

NOTE. Hardening by mechanical work is not included in this definition.

h. Tempering. Heating hardened, normalised, or mechanically worked steel to some temperature below the transformation range, and holding for a suitable time at that temperature, followed by cooling at a suitable rate. This process is usually applied for the purpose of producing a desired combination of mechanical properties. (See Stress Relieving.)

i. Case-hardening. Hardening the surface by changing its composition, followed by suitable heat treatment.

NOTE. (i) The term is usually applied to the carburising treatment or to the cyaniding treatment, with or without one or more further heatings for grain refinement, followed by quenching to produce a hard case.

(ii) Nitriding is a special form of case-hardening.

(iii) Flame and induction hardening are not included in this definition.

j. Blank carburising. The carburising procedure conducted without the carburising medium. (See Carburising.)

k. Nitriding. The introduction of nitrogen into the surface by heating to and holding at a suitable temperature below the transformation range in contact with partially dissociated ammonia or other suitable medium. This process produces a hard case without further heat treatment. (See Case-hardening.)

l. Blank nitriding. The nitriding procedure conducted without the carburising medium. (See Carburising.)

m. Cyaniding. The introduction of carbon and nitrogen into the surface by heating to and holding at a suitable temperature in contact with molten cyanides.

NOTE. Cyaniding is followed either by direct quenching from the cyaniding operation, or by other suitable heat treatment, to produce a hard case.

Additional definitions relating to the heat treatment of steel are included in Appendix D.

GENERAL DEFINITIONS

4. a. Yield stress. Yield stress is the lowest stress at which the elongation of the test piece increases without increase of load.

For practical purposes the yield stress is defined as the stress at which a visible permanent increase occurs in the distance between gauge points on the test piece observed when using the dividers ; or at which, when the load is increased at a moderately fast rate, there is a distinct drop of the testing machine lever, or in hydraulic machines, a hesitation in the movement of the gauge finger.*

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 materials concerned, but are not to be used as acceptance values except by special arrangement between the purchaser and the manufacturer.

It frequently happens especially with steels of tensile strength over 50 tons/sq. in. that the yield point is ill-defined. In the case of a steel which does not show a well defined yield point, the yield point is to be interpreted as the 'proof stress' corresponding to 0.5 per cent permanent elongation.

* From B.S. 18 'Tensile testing of metals.'

*b. Proof stress.** Proof stress is the stress which is just sufficient to produce a permanent elongation equal to a specified percentage of the original gauge length.

It can be determined (a) by direct measurements of the gauge length after various loads have been applied to the test piece and removed, or (b) from the load-elongation curve by drawing a line parallel to the straight portion of the curve, and distant from it by an amount representing the required permanent 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 have passed the proof test if, when the specified proof stress is applied to the test piece for a period of 15 seconds and removed, the test piece shall not have acquired a permanent elongation greater than the specified percentage of the gauge length.

c. Sample. A sample is that portion of the material selected for testing.

d. Test bar. A test bar is the sample after preparation for heat treatment.

e. Test piece. A test piece is the sample or test bar as finally prepared for testing.

f. Ruling section. In some of the following specifications indication is given of the size of round bar which will permit the attainment of certain mechanical properties in the given steel. It is essential when selecting the type of steel to be used that the designer should satisfy himself that the desired properties can be obtained in the sections dealt with. For any particular item being produced from the billet, bar, or forging supplied, that part which is most important from the point of view of the mechanical properties obtained after heat treatment, is characterised as the ruling section and the ruling section should always be referred to its equivalent in the form of round bar.[†]

g. Bright machining. Producing a bright bar by other means than cold drawing, i.e., turning, milling, grinding, etc.

MECHANICAL TESTS

5. *a.* Mechanical tests shall be conducted using testing machines that are maintained in good working condition and properly calibrated.

b. Tensile test. The tensile test shall be carried out in accordance with the requirements of B.S. 18.

Tensile test pieces from bars, billets, forgings and drop-forgings shall conform to the dimensions of British Standard test piece C, or if the test bar is too small, to the dimensions of the largest round subsidiary test piece that can be obtained (see Appendix B, p. 142) having a gauge length equal to four times the square root of the area.

* From B.S. 18 'Tensile testing of metals.'

† See information on ruling section in Appendix C, page 146.

Tensile tests may be carried out on wire test pieces without any preliminary machining when the wire is $\frac{5}{16}$ in. in diameter or less with a gauge length equal to four times the square root of the area.

c. Izod impact test. The Izod impact test shall be carried out in accordance with the requirements laid down in B.S. 131 (see figs. 4 to 10, Appendix B, page 142).

d. Nicked fracture test. For sizes less than $\frac{1}{2}$ in. in diameter or thickness a nicked fracture test may be substituted for the Izod impact test.

A test piece or bar, nicked or sawn so that the area of the portion of the bar to be fractured is not less than one-half of the original sectional area, must be free from defects when broken by a minimum number of blows.

e. Bend test. For sizes less than $\frac{3}{16}$ in. in diameter or thickness a bend test may be substituted for the nicked fracture test.

f. Hardness tests. The hardness test shall be carried out either in accordance with B.S. 240, 'Methods and tables for Brinell hardness,' using a 10 mm. diameter ball, and a load of 3000 kg. where possible, 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 stated in B.S. 860 shall be accepted.

For the steels covered by the present specifications, values for the Brinell hardness are quoted in italics. These values are considered to be representative for the materials concerned, and are based on the arbitrary formula ultimate tensile stress divided by 0.22, covering a 10-ton range. They are for guidance only and are not part of the contractual obligations defined by these specifications; purchasers who require guaranteed B.H.N. values must arrange with the supplier accordingly.

In practice there may be divergence between the calculated hardness numbers and those obtained from the hardness test. Where the hardness number is required as an indication of uniformity, the hardness test should be made on the tensile test piece, and the ratio thus obtained by dividing the ultimate tensile stress by the Brinell hardness number should be taken as the criterion in determining the hardness range of the material equivalent to the desired tensile range.

g. Transverse properties. In the present series of specifications mechanical properties for bars and billets in a transverse direction are not stated and the values quoted all refer to longitudinal tests. Where mechanical properties in the transverse direction are required, some modifications are necessary appropriate to each case. The changes will in general be in the direction of reducing the elongation and the Izod impact values, and the order of the modification is essentially governed by the size, form and type of material involved. Where it is agreed that such tests are necessary, suitable values should be agreed upon in each case between the purchaser and the manufacturer.

PROVISION OF TEST PIECES

6. When ordering steel not supplied in the finally treated condition the ruling section of the parts as heat treated should be stated.

Unless otherwise specified, samples for test purposes shall be prepared as follows :

a. Location of test piece. For bars, billets, forgings and drop-forgings the longitudinal axis of the test pieces shall be parallel to the axis of the piece in the direction in which the metal is most drawn out.

(i) For ruling sections up to and including $1\frac{1}{2}$ in. the test pieces shall be machined concentrically from the test bars.

(ii) For ruling sections over $1\frac{1}{2}$ in. and up to and including $2\frac{1}{2}$ in., the longitudinal axes of the test pieces shall be not less than $\frac{1}{16}$ in. from the surface of the test bars.

(iii) For ruling sections over $2\frac{1}{2}$ in. the longitudinal axes of the test pieces shall coincide with a position midway between the centre and the surface of the test bars.

The test pieces must be cut from the heat treated bars or forgings subsequent to heat treatment. In cases where the specified minimum ultimate tensile stress is not less than 85 tons per sq. in., the test bar shall be machined to test piece size, plus a grinding allowance, if required, before heat treatment. In such cases paragraphs (i), (ii), and (iii) above need not apply and the properties obtained are representative of those for parts heat treated in the same section as the test piece and do not represent larger sections.

b. Bars or billets for forging. Test samples may be taken from material in bar or billet sections where this does not differ appreciably as regards ruling section from that of the forgings to be produced. Where it is considered by either the purchaser or the manufacturer that owing to the nature of the steel and the dimensions of the forging the results of testing in bar or billet size would not be representative of the properties that would be obtained on the actual forgings, then test samples shall be prepared by forging special test bars of diameter equivalent to the ruling section of the forgings at the time of heat treatment. Such test samples shall then be given the representative heat treatment for the parts concerned.

Unless otherwise agreed, one tensile test and one impact test shall be taken from any batch of bars or billets of similar sizes from the same cast. For the purpose of subsequent orders, this test sample shall be accepted as representing all sizes of bars and billets from the same cast where the ruling section of the forgings does not exceed the diameter of the sample already tested.

c. Bars for machining not supplied in the finally heat treated condition. Test samples may be heat treated in the size as cut from the bars or they may be forged and/or machined to the ruling section of the parts and heat treated in that size. Where it is necessary to remove the surface, they shall be heat treated as near that size as possible.

Unless otherwise agreed, one tensile test and one impact test shall be taken from any batch of bars of similar sizes from the same cast. For the purpose of subsequent orders, this test sample shall be accepted as representing all sizes of bars from the same cast where the ruling section of the parts does not exceed the diameter of the sample already tested.

d. Bars for machining supplied in the finally heat treated condition. The sample shall be cut from the bar and shall not be further heat treated or mechanically worked after its removal from the bar.

Material for which the specified minimum ultimate tensile stress is not less than 85 tons per sq. in. should have test pieces separately prepared as in clause 6a.

Unless otherwise agreed, the number of tensile and impact tests taken from any batch of bars of similar sizes from the same cast and heat treated together, should be 2 per cent of the number of bars, whilst the number of bars subjected to Brinell test should be not less than 10 per cent. In any case the number of tests required per cast or heat treatment batch should be stated on the order.

*e. Large forgings and large drop-forgings.** Where integral test samples are specified by the purchaser, unless otherwise arranged, the diameter of the prolongation to form the test bar left on the forging or drop-forging shall approximate to the ruling section of the forging or drop-forging at the time of heat treatment, and except as specified in para. (ii) below shall not be finally severed until after the heat treatment of the forging or drop-forging.

(i) *Length of prolongation.* In general where only tensile tests are required the prolongation shall be not less than 7 in. long. Where both tensile and Izod impact tests are required the prolongation shall be not less than 11 in. long, unless such prolongation is $2\frac{1}{2}$ in. or over in width or diameter, in which case a length of 7 in. is sufficient.

(ii) *Case hardening steels.* To avoid difficulty in machining case hardening steel, the prolongation may be marked for identification with its forging and severed prior to heat treatment, and carburisation of the test bar substituted by blank carburising or, by agreement, omitted altogether, but its subsequent heat treatment shall be carried out simultaneously with and similarly to the forging or drop-forgings it represents.

When integral test samples are not specified, separate test samples shall be provided from the steel from which the forgings are produced. They shall be forged and/or machined to the ruling section of the forgings before heat treatment, and shall be of sufficient length to provide the test pieces required. They shall be heat treated similarly to and simultaneously with the forgings they represent.

f. Small forgings and small drop-forgings (ruling section not greater than $1\frac{1}{2}$ in. diameter). A separate test bar representing the same cast as

* These specifications are confined to bars, billets, stampings and light forgings up to 6 in. ruling section.

Also see note in clause 2 d, page 9.

used for the forgings shall be employed. This test bar shall be $1\frac{1}{2}$ in. diameter, or the full size of the original bar if less than $1\frac{1}{2}$ in., and shall be similarly and simultaneously heat treated with the forgings which it represents, and the test piece shall be machined from it after heat treatment. The sample provided for the preparation of test bars shall be not less than 7 in. long for tensile, and not less than 11 in. long for tensile and Izod impact tests.

g. Test bars for case-hardening steel. The mechanical tests specified for case-hardening steel shall be made on the core of a case-hardened test bar of $1\frac{1}{2}$ in. diameter, or a similar non-carburised test bar which has been blank carburised, refined and hardened as specified in the individual specification. Blank carburising may be omitted by agreement between the purchaser and the manufacturer.

When the test bar is smaller than $1\frac{1}{2}$ in. the mechanical properties stated in the individual specification may be modified. The extent of the modification shall be determined by experiments on test bars from the same cast $1\frac{1}{2}$ in. diameter and the size of the test bars respectively.

h. Test bars for case-hardened forgings, drop-forgings and parts. Carburisation of the test bars representing case-hardened forgings, drop-forgings and parts may be omitted, but the heat treatment otherwise shall be carried out simultaneously with and similarly to the forgings or parts they represent.

HEAT TREATMENT OF BARS AND BILLETS FOR FORGING AND OF FORGINGS AND DROP-FORGINGS

7. Generally, bars and billets for forging are required to be delivered in the as rolled or forged condition unless the order states otherwise. It is recognised, however, that for certain steels possessing definite air-hardening characteristics there may be liability to set up a dangerous condition in the bars or billets if they are allowed to cool after hot-working without some care being given to the conditions of cooling. It is incumbent upon the manufacturer in such cases to take suitable steps to ensure that the condition in which the materials are supplied shall be reasonably safe. For this purpose the manufacturer may employ a controlled rate of cooling after hot working or alternatively may apply a reheating operation for the purpose of softening or for minimising residual internal stresses in the steels.

In the case of forgings and drop-forgings the condition in which the parts are supplied is affected in some cases by the desire to have a machinable condition. Such a condition may be the final heat treated condition, or alternatively a softened or annealed condition, as provided in the individual specifications, or as arranged between the purchaser and the manufacturer.

If for any forgings or drop-forgings, machinability as supplied is not in question, then they may be supplied as forged (unless otherwise

arranged), subject to being rendered reasonably safe as indicated above for bars and billets.

ALTERNATIVE TREATMENT FOR CASE-HARDENING STEELS

8. 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 $760^{\circ}/800^{\circ}\text{C.}$ 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. Another alternative heat treatment which is occasionally employed is that of quenching direct from the carburising treatment, but this is not recommended.

MARGINS OF MANUFACTURE

9. The margins of manufacture for steel bars for machining shall be in accordance with those given in tables 6, 7 and 8 (pages 137, 138 and 139).

INSPECTION

10. The representative of the engineer (or of the purchaser) shall have reasonable access to the works of the manufacturer for the purpose of inspection of the manufacture at various stages.

TESTING FACILITIES

11. The manufacturer shall supply the material required for testing free of charge, 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 schedule. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the test elsewhere.

RETESTS

12. 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 or billet from which the original test sample was taken, unless that bar or billet has been withdrawn by the manufacturer.

In the case of material supplied in the heat treated condition the manufacturer shall have the right to re-heat treat the material before the two further samples are selected.

Should the two further tests satisfy the requirements of the mechanical tests, the material represented by the tests shall be accepted. Should either of the retests fail, the material represented shall be liable to rejection.

TENSILE RANGE REFERENCE SYMBOLS FOR HARDENED AND TEMPERED MATERIAL

The varying tensile ranges for the different specifications have been designated with the letters N 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.)
N.	30	U.	60
P.	35	V.	65
Q.	40	W.	70
R.	45	X.	75
S.	50	Y.	80
T.	55	Z.	100

TABLE 1. CARBON STEELS FOR BARS, BILLETS, LIGHT FORGINGS AND STAMPINGS UP TO 6 IN. RULING SECTION

Speci- cation	Finish	Chemical composition						U.T.S.	Ruling section	Remarks
		Carbon	Silicon	Manganese	Nickel	Sulphur	Phosphorus			
En. 1A	Cold drawn	0.07/0.15	0.10 max.	0.80/1.20	—	0.20/0.30	0.07 max.	32	Up to and incl. 1 3/32 in.	—
	Other finishes							28 25 23	1 3/32 in.—1 1/2 in. 1 1/2 in.—2 1/2 in. 2 1/2 in.—4 in.	—
En. 1B	Cold drawn	0.07/0.15	0.10 max.	1.00/1.40	—	0.30/0.60	0.06 max.	27	Up to and incl. 1 3/32 in.	—
	Other finishes							25 23	1 3/32 in.—1 1/2 in. 1 1/2 in.—2 1/2 in.	—
En. 2	As rolled	0.20 max.	—	0.80 max.	—	0.06 max.	0.06 max.	20	—	—
En. 3	As rolled	0.25 max.	0.05/0.35	1.00 max.	—	0.06 max.	0.06 max.	25/35	—	—
En. 3A	Finishes other than cold drawn	0.15/0.25	0.05/0.35	0.40/0.90	—	0.06 max.	0.06 max.	28	—	—
En. 3B	Cold drawn	0.25 max.	0.35 max.	1.10 max.	—	0.06 max.	0.06 max.	28	—	—

TABLE 1. CARBON STEELS FOR BARS, BILLETS, LIGHT FORGINGS AND STAMPINGS UP TO 6 IN.

RULING SECTION (continued).

S, sec. 1- ation	Finish	Chemical composition						U.T.S.	Ruling section	Remarks
		Carbon	Silicon	Manganese	Nickel	Sulphur	Phosphorus			
En. 4	Normalised	0.30 max.	0.05/0.35	1.10 max.	—	0.06 max.	0.06 max.	28/38	—	—
En. 4A	Cold drawn	0.30 max.	0.05/0.35	1.10 max.	—	0.06 max.	0.05 max.	32/42	2 in.	—
En. 5	Hardened and tempered	0.25/0.35	0.05/0.35	0.60/1.10	—	0.06 max.	0.06 max.	30 35 40 45	2½ in. 2 in. 1½ in. ¾ in.	Range N. Range P. Range Q. Range R.
En. 5A	Supplied to composition only	0.25/0.30 0.28/0.33 0.30/0.35	0.05/0.35 0.05/0.35 0.05/0.35	0.70/0.90 0.70/0.90 0.70/0.90	— — —	0.06 max. 0.06 max. 0.06 max.	0.06 max.	—	—	—
En. 5B	Supplied to composition only	0.25/0.30 0.28/0.33 0.30/0.35	0.05/0.35 0.05/0.35 0.05/0.35	0.70/0.90 0.70/0.90 0.70/0.90	— — —	0.06 max. 0.06 max. 0.06 max.	0.06 max.	—	—	—
En. 5D	Hardened and tempered and cold drawn	0.25/0.35	0.05/0.35	0.60/1.10	—	0.06 max.	0.06 max.	45 40 35	Up to and incl. ½ in. ¾ in. 1½ in.	—
En. 6	Bright	0.40 max.	0.05/0.35	0.50/0.90	—	0.06 max.	0.06 max.	35/45	—	—
En. 6A	Bright	0.40 max.	0.05/0.35	0.50/0.90	—	0.06 max.	0.06 max.	35/45	—	No lrod
En. 7	Cold drawn	0.10/0.30	0.35 max.	0.70/1.30	—	0.10/0.18	0.06 max.	35/45	Up to and incl. 1½ in.	Note. For sizes 1½ in.—2½ in. U.T.S. 30/40

En. 8	As rolled or normalised	0.35/0.45	0.05/0.35	0.60/1.10	—	0.06 max.	0.06 max.	35	6 in.	Range Q.
En. 8A	Supplied to composition only	0.33/0.38	0.05/0.35	0.70/0.90	—	0.06 max.	0.06 max.	—	—	—
En. 8B	0.35/0.40 0.38/0.43 0.40/0.45 0.40/0.45	0.05/0.35 0.05/0.35 0.05/0.35 0.05/0.35	0.70/0.90 0.70/0.90 0.70/0.90 0.70/0.90	— — — —	0.06 max. 0.06 max. 0.06 max. 0.06 max.	0.06 max.	0.06 max.	—	—	—
En. 8M	As rolled or normalised	0.35/0.45	0.25 max.	0.90/1.10	—	0.12/0.20	0.07 max.	35	6 in.	Range Q.
En. 9	Normalised	0.50/0.60	0.05/0.35	0.50/0.80	—	0.06 max.	0.06 max.	45 50/65	4 in. 1½ in. 2 in.	Range S.
En. 14A	Normalised	0.15/0.25	0.10/0.35	1.30/1.70	0.40 max. Chromium 0.25 max.	0.06 max.	0.06 max.	35	6 in.	—
En. 14B	Hardened and tempered	0.15/0.25	0.10/0.35	1.30/1.70	0.40 max.	0.06 max.	0.06 max.	40 45 45	4 in. 1½ in. 2 in.	Range Q.
En. 14B	Normalised and tempered and cold drawn	0.20/0.30	0.10/0.35	1.30/1.70	0.40 max.	0.06 max.	0.06 max.	38 40 45	6 in. 4 in. 2½ in.	Range Q.

TABLE 1. CARBON STEELS FOR BARS, BILLETS, LIGHT FORGINGS AND STAMPINGS UP TO 6 IN.
RULING SECTION (continued)

Specifi- cation	Finish	Chemical composition							U.T.S.	Ruling section	Remarks
		Carbon	Silicon	Manganese	Nickel	Sulphur	Phosphorus				
En. 15A	Hardened and tempered	0.30/0.40	0.05/0.35	1.30/1.70	—	0.06 max.	0.06 max.	40 45 50	4 in. 2 1/2 in. 1 1/2 in.	Range O. Range R. Range S.	
En. 15B	Hardened and tempered	0.35/0.40	0.05/0.35	1.10/1.30	—	0.06 max.	0.06 max.	40 45 50 55	4 in. 2 1/2 in. 1 1/2 in.	Range O. Range R. Range S. Range T.	
En. 43A	Hardened and tempered Normalised Cold drawn	0.45/0.55	0.05/0.35	0.70/1.00	—	0.06 max.	0.06 max.	40 50 55/60	1 1/2 in. 1 1/2 in.	Range S.	—
En. 43 B	Supplied to composition only	0.45/0.50	0.05/0.35	0.70/1.00	—	0.06 max.	0.06 max.	—	—	—	—
E D C		0.50/0.55 0.60/0.65 0.65/0.70	0.05/0.35 0.05/0.35 0.05/0.35	0.70/1.00 0.40/0.60 0.70/0.90	— — —	0.06 max. 0.06 max. 0.06 max.	0.06 max. 0.06 max. 0.06 max.				

TABLE 2. ALLOY STEELS FOR HARDENING AND TEMPERING,
BARS, BILLETS, LIGHT FORGINGS AND
The mechanical properties specified are obtainable
within the limits of ruling section given below

B.S. No.	Type of steel	C.	Si.	Mn.	Ni.	Cr.	Mo.
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. 14A and En. 14B	Carbon-manganese	0.15/ 0.25	0.10/ 0.35	1.30/ 1.70	0.40 max.	0.25 max.	—
En. 15	Carbon-manganese (higher tensile)	0.20/ 0.30	0.10/ 0.35	1.30/ 1.70	0.40 max.	—	—
En. 16	Manganese-molybdenum	0.30/ 0.40	0.10/ 0.35	1.30/ 1.70	—	—	—
En. 17	Manganese-molybdenum (higher molybdenum)	0.25/ 0.40	0.10/ 0.35	1.30/ 1.80	—	—	0.20/ 0.35
En. 18	1 per cent chromium	0.30/ 0.40	0.10/ 0.35	1.30/ 1.80	—	—	0.35/ 0.55
En. 19	1 per cent chromium- molybdenum	0.35/ 0.45	0.10/ 0.35	0.60/ 0.95	—	0.80/ 1.10	—
En. 19A	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. 21	3 per cent nickel	0.25/ 0.35	0.10/ 0.35	0.35/ 0.75	2.75/ 3.50	0.30 max.	—
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. 23	3 per cent nickel- chromium	0.25/ 0.35	0.10/ 0.35	0.45/ 0.70	2.75/ 3.75	0.50/ 1.00	0.65 max. (opt.)
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. 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

40 TO 100 TONS PER SQ. IN. ULTIMATE TENSILE STRESS
STAMPINGS UP TO 6 IN. RULING SECTION
within the limits of ruling section given below

40/50 tons tensile Q	45/55 tons tensile R	50/60 tons tensile S	55/65 tons tensile T	60/70 tons tensile U	65/75 tons tensile V	70/80 tons tensile W	75/85 and 80/90 tons tensile X & Y	100 tons min. tensile Z
All sizes	—	—	—	—	—	—	—	—
All sizes	—	—	—	—	—	—	—	—
Up to 4 in.	Up to 1½ in.	—	—	—	—	—	—	—
Up to 4 in.	Up to 2½ in.	—	—	—	—	—	—	—
All sizes	Up to 2½ in.	Up to ¾ in.	—	—	—	—	—	—
—	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	Up to ¾ in.	—	—	—
—	All sizes	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	—	—	—
—	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	—	—	—	—	—
—	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	Up to ¾ in.	Up to 1½ in.	—	—
—	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	Up to ¾ in.	—	—	—
—	Up to 4 in.	Up to 2½ in.	—	—	—	—	—	—
—	—	Up to 4 in.	Up to 2½ in.	—	—	—	—	—
—	—	All sizes	All sizes	All sizes	Up to 2½ in.	—	—	—
—	—	All sizes	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in. if oil hardened	Up to 1½ in.	Up to 1½ in. if oil hardened.
—	—	—	All sizes	All sizes	All sizes	Up to 4 in.	Up to 2½ in.	Up to 2½ in. if oil hardened.

TABLE 2. ALLOY STEELS FOR HARDENING AND TEMPERING, 40
BARS, BILLETS, LIGHT FORGINGS AND

The mechanical properties specified are obtainable

B.S. No.	Type of steel	C.	Sl.	Mn.	Ni.	Cr.	Mo.
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. 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. 29	3 per cent chromium-molybdenum	0.15/ 0.35	0.10/ 0.35	0.65 max.	0.40 max.	2.50/ 3.50	0.30/ 0.70
En. 30A and En. 30B	4¼ per cent nickel-chromium and 4¼ 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
En. 100	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
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. 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

TO 100 TONS PER SQ. IN. ULTIMATE TENSILE STRESS (continued)
STAMPINGS UP TO 6 IN. RULING SECTION

within the limits of ruling section given below

40/50 tons tensile Q	45/55 tons tensile R	50/60 tons tensile S	55/65 tons tensile T	60/70 tons tensile U	65/75 tons tensile V	70/80 tons tensile W	75/85 and 80/90 tons tensile X & Y	100 tons min. tensile Z
—	—	—	—	All sizes	All sizes	All sizes	All sizes	Up to 4 in. if oil hardened.
—	—	—	All sizes	All sizes	All sizes	Up to 4 in.	—	—
—	—	—	—	All sizes	All sizes	Up to 4 in.	Up to 2½ in.	—
—	All sizes	All sizes	All sizes	All sizes	Up to 4 in.	Up to 4 in.	—	Up to 2½ in. if oil hardened.
—	—	—	—	—	—	—	—	Up to 2½ in. if air hardened. Up to 6 in. if oil hardened.
—	—	—	—	—	—	—	—	—
—	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	Up to 1½ in.	—	—	—
—	All sizes	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	Up to 1½ in.	—	—
—	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	—	—	—	—
—	All sizes	Up to 4 in.	Up to 2½ in.	Up to 1½ in.	—	—	—	—

TABLE 3. STEELS FOR CASE-HARDENING WITH CORE STRENGTHS OF 32 TO 85 TONS PER SQ. IN.

B.S. No.	Type of steel	C.	Si.	Mn.	Ni.	Cr.	Mo.	Specified core properties	
								Ultimate tensile stress tons/sq. in.	Impact ft. lbs.
En. 32A, En. 32B, and En. 32M	Carbon	0.15 max. 0.10/0.18 0.05/0.35	0.40/0.70 0.70/1.10 0.05/0.35	0.40/0.70 0.70/1.10 0.05/0.35	—	—	—	32	40
En. 33	Carbon (semi-free cutting)	0.10/0.18	0.05/0.35	0.70/1.10	—	—	—	32	40
En. 34	2 per cent nickel-molybdenum (lower C)	0.14/0.20	0.10/0.35	0.30/0.60	1.50/2.00	—	0.20/0.30	45	40
En. 35	2 per cent nickel-molybdenum (higher C)	0.20/0.28	0.10/0.35	0.30/0.60	1.50/2.00	—	0.20/0.30	55	25
En. 36	3 per cent nickel-chromium	0.18 max.	0.10/0.35	0.30/0.60	3.00/3.75	0.60/1.10	—	55	35
En. 37	5 per cent nickel	0.16 max.	0.10/0.35	0.45 max.	4.5/5.2	0.30 max.	—	40	50
En. 38	5 per cent nickel	0.16 max.	0.10/0.35	0.60 max.	4.5/5.5	0.30 max.	0.15/0.30 (opt.)	65	30
En. 39A and En. 39B	4½ per cent nickel-chromium	0.12/0.18	0.10/0.35	0.50 max.	2.80/4.50	1.00/1.40	—	85	25
En. 201	Carbon-manganese	0.18 max.	0.05/0.35	1.10/1.50	—	—	—	40	40
En. 202	Carbon-manganese free- machining	0.18 max.	0.05/0.35	1.10/1.50	—	—	—	38	30
En. 320	2 per cent nickel-chromium- molybdenum	0.14/0.20	0.10/0.35	0.40/0.70	1.80/2.20	1.80/2.20	0.15/0.25	85	25
En. 325	Low nickel-chromium molybdenum	0.17/0.22	0.10/0.35	0.45/0.65	1.50/2.0	0.40/0.60	0.20/0.30	55	35

TABLE 4. SUMMARY OF SPRING STEELS

B.S. No.	Type of steel	C.	Si.	Mn.	Cr.	V.	S.	P.
En. 42	Carbon	0.70/ 0.85	0.10/ 0.40	0.55/ 0.75	—	—	0.05 max.	0.05 max.
En. 43	Carbon	0.45/ 0.60	0.10/ 0.40	0.60/ 0.80	—	—	0.05 max.	0.05 max.
En. 44	Carbon (higher carbon content)	0.90/ 1.20	0.30 max.	0.45/ 0.70	—	—	0.05 max.	0.05 max.
En. 45	Silicon-manganese	0.50/ 0.65	1.50/ 2.00	0.70/ 1.00	—	—	0.05 max.	0.05 max.
En. 45A	Silicon-manganese	0.53/ 0.63	1.70/ 2.00	0.70/ 1.00	—	—	0.05 max.	0.05 max.
En. 46	Silicon-manganese	0.35/ 0.45	1.50/ 2.00	0.60/ 1.00	—	—	0.05 max.	0.05 max.
En. 47	1 per cent chromium-vanadium	0.45/ 0.55	0.50 max.	0.50/ 0.80	0.80/ 1.20	0.15 min.	0.05 max.	0.05 max.
En. 48	1 per cent chromium	0.45/ 0.55	0.10/ 0.50	0.50/ 0.80	1.00/ 1.40	—	0.05 max.	0.05 max.

FREE CUTTING STEEL BARS FOR MACHINING

Chemical composition. The steel shall contain :

Carbon	not less than 0.07 and not more than 0.15 per cent.
Silicon	not more than 0.10 per cent.
Manganese	not less than 0.80 and not more than 1.20 per cent.
Sulphur	not less than 0.20 and not more than 0.30 per cent.
Phosphorus	not more than 0.07 per cent.

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 the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :

Cold rolled or cold drawn

Ruling section	Ultimate tensile strength, tons per sq. in., not less than	Elongation, per cent, not less than
Up to and including $1\frac{1}{32}$ in.	32	10
Over $1\frac{1}{32}$ in. up to and including $1\frac{1}{2}$ in.	28	14
Over $1\frac{1}{2}$ in. up to and including $2\frac{1}{2}$ in.	25	14
Over $2\frac{1}{2}$ in. up to and including 4 in.	23	14

As rolled or bright finished (other than cold rolled or cold drawn)

Ruling section	Ultimate tensile strength, tons per sq. in., not less than	Elongation, per cent, not less than
Up to and including 4 in.	23	26

This steel is sometimes used for parts which are to be case-hardened. In such cases the heat treatment should follow the procedure given under B.S. En. 32A, and the mechanical properties to be expected in the core will be as follows :

Ultimate tensile stress,	
Tons per sq. in.	not less than 23
Elongation, per cent	not less than 20
Izod impact value, ft. lb.	not less than 25

FREE CUTTING STEEL BARS FOR MACHINING

Chemical composition. The steel shall contain :

Carbon	not less than 0.07 and not more than 0.15 per cent.
Silicon	not more than 0.10 per cent.
Manganese	not less than 1.00 and not more than 1.40 per cent.
Sulphur	not less than 0.30 and not more than 0.60 per cent.
Phosphorus	not more than 0.06 per cent.

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 the test pieces selected and prepared as stated in the appropriate general clauses shall be as follows :

Cold rolled or cold drawn

Ruling section	Ultimate tensile strength, tons per sq. in., not less than	Elongation, per cent, not less than
Up to and including $1\frac{1}{32}$ in.	27	10
Over $1\frac{1}{32}$ in. up to and including $1\frac{1}{2}$ in.	25	12
Over $1\frac{1}{2}$ in. up to and including $2\frac{1}{2}$ in.	23	12

As rolled or bright finished (other than cold rolled or cold drawn)

Ruling section	Ultimate tensile strength, tons per sq. in., not less than	Elongation, per cent, not less than
Up to and including $2\frac{1}{2}$ in.	23	24

This steel is sometimes used for parts which are to be case-hardened. In such cases the heat treatment should follow the procedure given under B.S. En. 32A, and the mechanical properties to be expected in the core will be as follows :

Ultimate tensile stress,	
Tons per sq. in.	not less than 28
Elongation, per cent	not less than 20
Izod impact value, ft. lb.	not less than 25

GENERAL PURPOSE COLD FORMING STEEL

(See B.S. † for steel wire for cold forging.)

(NOTE. This steel, En. 2, corresponds to En. 2A steel in the 1942 edition. Steel En. 3A provides for a steel of the quality covered by En. 2 in the 1942 edition.)

En. 2. Chemical composition. The steel shall contain :

Carbon not more than 0.20 per cent.
Manganese not more than 0.80 per cent.
Sulphur not more than 0.06 per cent.
Phosphorus not more than 0.06 per cent.

Condition of material on delivery. Bars shall be delivered in the as rolled 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.

Ultimate tensile stress,

tons per sq. in. not less than 20

Elongation, per cent not less than 28

Bend test (180° bend) $\frac{3}{4}$ t

Steels for special applications. Steel of this type may also be required in the form of bar, plate, sheet and strip for deep drawing and other cold forming operations (see B.S. ‡), the chemical composition of these steels is given below. It is desirable to consult the steel maker regarding the most satisfactory specification for the purpose.

	C.	Mn.	S.	P.
En. 2A	0.12 max.	0.50 max.	0.05 max.	0.05 max.
En. 2A/1	0.10 max.	0.50 max.	0.04-0.05 max.	0.04-0.05 max.
En. 2B	0.15 max.	0.50 max.	0.05 max.	0.05 max.
En. 2C	0.15/0.25	0.40/0.60	0.05 max.	0.05 max.
En. 2D	0.15/0.30	0.40/0.70	0.05 max.	0.05 max.

† In course of preparation.

(BS 1449 Steel plate, sheet & strip)
2C/2 steel plate, sheet & strip only in BS 1449

• 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 to 35 tons per sq. in.

Chemical composition. The steel shall contain :

Carbon not more than 0.25 per cent.
Silicon not less than 0.05 and not more than 0.35 per cent.
Manganese not more than 1.00 per cent.
Sulphur not more than 0.06 per cent.
Phosphorus not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the as forged condition, unless the order states otherwise (see clause 7, page 16).

(iii) Bars for machining shall be delivered in the as rolled 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. dia. 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.

Ultimate tensile stress,

tons per sq. in. not less than 25 and not more than 35

Elongation, per cent. not less than 25

'20' CARBON STEEL (HOT ROLLED OR NORMALISED)

(This steel is the same as En. 2 in the 1942 edition)

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

Suitable for a tensile range of 28 to 33 tons per sq. in. in the normalised condition.

The purchaser should state on the order in which condition the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.15 and not more than 0.25 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.40 and not more than 0.90 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition unless the order states otherwise (see clause 7, page 16).

(iii) Bars for machining shall be delivered in one of the following conditions as the order shall state :

- Hot rolled—as rolled condition.
- Hot rolled—normalised.
- Bright finish (other than cold drawn)—as rolled condition.
- Bright finish ~~(other than cold drawn)~~—normalised.

Heat treatment. The heat treatment to be given to the test bars, selected as specified in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

Normalise at a temperature between 880°C. and 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 :

Ultimate tensile stress,	
tons per sq. in.	not less than 28
Elongation, per cent	not less than 25

'20' CARBON STEEL (COLD DRAWN)

BRIGHT BARS FOR MACHINING

Suitable for a tensile strength of not less than 28 tons per sq. in. in the cold drawn condition.

If a cold drawn steel of 35 tons tensile strength is required, En. 6 or En. 6A should be specified.

Chemical composition. The steel shall contain :

Carbon	not more than 0.25 per cent.
Silicon	not more than 0.35 per cent. <u>1.00</u>
Manganese	not more than ~~0.40~~ per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. All 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 :

Ultimate tensile stress,	
tons per sq. in.	not less than 28
Elongation, per cent	not less than 17

25' CARBON STEEL (COLD DRAWN)

BRIGHT BARS FOR MACHINING

Chemical composition. The steel shall contain :

Carbon	not more than 0.30 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not more than 1.10 per cent. 1.00%
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. Bars for machining 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.

Limiting ruling section 2 in.

Ultimate tensile stress,

tons per sq. in. not less than 32 and not more than 42

Elongation, per cent not less than 12

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

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 to 38 tons per sq. in.

Chemical composition. The steel shall contain :

Carbon	not more than 0.30 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not more than 1.10 per cent. 1.00%
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

(iii) Bars for machining 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 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

Normalise at a temperature of between 850°C. and 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. dia. 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.

Ultimate tensile stress,

tons per sq. in. not less than 28 and not more than 38

Elongation, per cent

not less than 25

Izod impact value, ft. lb.

not less than 20

(for bars 2½ in. ruling

section and under)

Brinell hardness number

126/179

* 30' CARBON STEEL (HARDENED AND TEMPERED)

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

Suitable for tensile ranges of 30/40 (N), 35/45 (P), 40/50(Q) and 45/55 (R) tons per sq. in. The purchaser should state on the order, for which condition, N, P, Q or R, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.25 and not more than 0.35 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.60 and not more than 1.10 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

(iii) Bars for machining 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 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

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 :

Limiting ruling section	N	P	Q	R
Ultimate tensile stress } tons per sq. in. not less than	2 1/2 in.	2 1/2 in.	3/4 in.	1/2 in.
Yield stress, tons per sq. in. not less than	30	35	40	45
Elongation, per cent not less than	17	20	25	32
Izod impact value, ft. lb. not less than	27	22	18	20
Brinell hardness number	131/187	152/207	179/229	201/255

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

Steels for special applications. For special applications the steel may be ordered to specification En. 5A, En. 5B and En. 5C, when it will be supplied to a specified composition only, the limits of which are shown in table 1, page 20. Mechanical properties are not part of the contractual obligations of specifications En. 5A, En. 5B and En. 5C.

* 30' CARBON STEEL (HARDENED AND TEMPERED)

BARS FOR MACHINING (BRIGHT DRAWN)

Chemical composition. The steel shall contain :

Carbon	not less than 0.25 and not more than 0.35 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.60 and not more than 1.10 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. Bars for machining 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 :

Limiting ruling section	Up to 1/2 in.	3/4 in.	1 1/4 in.	1 1/2 in.	2 1/2 in.
Ultimate tensile stress, tons per sq. in.	not less than 45	40	35	35	35
Yield stress, tons per sq. in.	not less than 32	25	—	—	—
Elongation, per cent	not less than 20	18	15	15	15
Izod impact value, ft. lb.	not less than 40	20	15	10	10
Brinell hardness number	not more than 255	229	229	229	229

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

35/45 TON BRIGHT CARBON STEEL

BARS FOR MACHINING

Chemical composition

En. 6. The steel shall contain :

Carbon	not more than 0.40 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.50 and not more than 0.90 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 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 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 :

Ultimate tensile stress, tons per sq. in.	not less than 35 and not more than 45
Elongation, per cent	not less than 15
Izod impact value, ft. lb. up to and including $\frac{3}{4}$ in. in diameter (or width across flats)	not less than 20
over $\frac{3}{4}$ in. up to and including $1\frac{1}{2}$ in. in diameter (or width across flats)	not less than 15
over $1\frac{1}{2}$ in. in diameter (or width across flats)	not less than 10

Mass effect. The effect of mass is chiefly reflected in the difference to be expected in the Izod impact values in various sizes. Except in those cases where the bright finish is produced by machining or grinding material in the as rolled or normalised 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 above is applied after cold working.

En. 6A. When this steel is required without any specified Izod impact value 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.

35/45 TON BRIGHT CARBON STEEL (SEMI-FREE CUTTING)

(Not recommended for case hardening)

BRIGHT BARS FOR MACHINING

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

Chemical composition. The steel shall contain :

Carbon	not less than 0.10 and not more than 0.30 per cent.
Silicon	not more than 0.35 per cent.
Manganese	not less than 0.70 and not more than 1.30 per cent.
Sulphur	not less than 0.10 and not more than 0.18 per cent.
Phosphorus	not more than 0.06 per cent.

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.

NOTE. If 'other finishes' are required, En. 8M should be specified.

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	$1\frac{1}{4}$ in.
Ultimate tensile stress, tons per sq. in.	not less than 35 and not more than 45
Elongation, per cent	not less than 15
Izod impact value, ft. lb. up to and including $\frac{3}{4}$ in. in diameter (or width across flats)	not less than 20
over $\frac{3}{4}$ in. up to and including $1\frac{1}{2}$ in. in diameter (or width across flats)	not less than 15
over $1\frac{1}{2}$ in. up to and including $1\frac{3}{4}$ in. in diameter (or width across flats)	not less than 10

Mass effect. The effect of mass is chiefly reflected in the difference to be expected in the Izod impact value in various sizes. Except in those cases where the bright finish is produced by machining or grinding material in the as rolled or normalised 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 above is applied after cold working.

NOTE. If mechanical properties for sizes above $1\frac{3}{4}$ in. diameter are required they should be as follows :

Limiting ruling section	$1\frac{3}{4}$ - $2\frac{1}{2}$ in.
Ultimate tensile stress, tons per sq. in.	not less than 30 and not more than 40
Elongation, per cent	not less than 12
Izod impact value, ft. lb.	not less than 10

See En. 8M, No. 5
for mech. properties

'40' CARBON 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 per sq. in., according to the ruling section of the part. The purchaser should state on the order for which condition, as rolled or normalised, cold drawn, or hardened and tempered, Q or R, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.35 and not more than 0.45 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.60 and not more than 1.00 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

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

b. Material required in the normalised condition :

Normalise at a temperature between 830°C. and 860°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	Normalised 6 in.	Cold drawn 1 1/2 in.	Q (H & T) 2 in.	R (H & T) 1/2 in.
Ultimate tensile stress, tons per sq. in.	not less than 35	38	40	45
Yield stress, tons per sq. in.	not less than 17	—	28	30
Elongation, per cent	not less than 20	12	22	20
Izod impact value, ft. lb.	not less than —	—	25	40

Brinell hardness number 152/207 229 max. 179/229 201/255

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

Steels for special applications. For special applications the steel 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 only, the limits of which are shown in table 1, page 21.

Mechanical properties are not part of the contractual obligations of specifications En. 8A, En. 8B, En. 8C, En. 8D and En. 8E.

'40' CARBON STEEL—FREE CUTTING

BARS AND BILLETS FOR FORGING
BARS FOR MACHINING
BRIGHT BARS

Suitable in the hardened and tempered condition for tensile ranges of 40/50 (Q), and 45/55 (R) tons per sq. in., according to the ruling section of the part.

The purchaser should state on the order for which condition, as rolled or normalised, cold drawn, or hardened and tempered, Q or R, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.35 and not more than 0.45 per cent.
Silicon	not more than 0.25 per cent. 1.20
Manganese	not less than 0.90 and not more than 1.10 per cent.
Sulphur	not less than 0.12 and not more than 0.20 per cent.
Phosphorus	not more than 0.07 per cent.

(i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

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

b. Material required in the normalised condition :
Normalise at a temperature between 830°C. and 860°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	Normalised 6 in.	Cold drawn 1½ in.	Q (H & T) 2 in.	R (H & T) ½ in.
Ultimate tensile stress, tons per sq. in.	not less than 35	38	40	45
Yield stress, tons per sq. in.	not less than 17	—	28	30
Elongation, per cent.	not less than 20	12	22	20
Izod impact value, ft. lb.	not less than —	—	2.5	40
Brinell hardness number	152/207	229 max.	179/229	201/255

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

'55' CARBON 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 50/60 (S) and 55/65 (T) tons per sq. in. The purchaser should state on the order for which condition, normalised, cold drawn, or hardened and tempered, S or T, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.50 and not more than 0.60 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.50 and not more than 0.80 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forgings shall be delivered as rolled or forged unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

a. Material required in the hardened and tempered condition :
Harden in oil from a temperature of 810°C. to 840°C.
Temper at a suitable temperature between 550°C. and 660°C.

b. Material required in the normalised condition :
Normalise at a temperature between 810°C. and 840°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	Normalised 4 in.	Cold drawn 2 in.	S (H & T) 1½ in.	T (H & T) 1½ in.
Ultimate tensile stress, tons per sq. in.	not less than 45	50	50	55
Yield stress, tons per sq. in.	not less than 22	—	30	35
Elongation, per cent.	not less than 18	12	18	15
Brinell hardness number	201/255	223/302	223/277	248/302

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

' 55 ' CARBON, ½ 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 only, the limits of which are as follows :

Chemical composition. The steel shall contain :

Carbon	not less than 0.50 and not more than 0.60 per cent.
Silicon	not less than 0.05 and not more than 0.35 per cent.
Manganese	not less than 0.50 and not more than 0.80 per cent.
Nickel	not less than 0.50 and not more than 0.80 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forgings shall be delivered as rolled or forged unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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.

Mechanical properties. Mechanical properties are not part of the contractual obligations of specification En. 10.

' 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 per sq. in. The purchaser should state on the order, for which condition, T or V, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.50 and not more than 0.70 per cent.
Silicon	not less than 0.10 and not more than 0.35 per cent.
Manganese	not less than 0.50 and not more than 0.80 per cent.
Chromium	not less than 0.50 and not more than 0.80 per cent.
Sulphur	not more than 0.05 per cent.
Phosphorus	not more than 0.05 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, 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 :

	T	V
Limiting ruling section	2½ in.	2½ in.
Ultimate tensile stress, tons per sq. in.	not less than 55	not less than 65
Yield stress, tons per sq. in.	not less than 38	not less than 45
Elongation, per cent	not less than 15	not less than 12
Izod impact value, ft. lb.	not less than 25	not less than 12
Brinell hardness number	248/302	293/341

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

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 per sq. in. The purchaser should state on the order for which condition, as rolled or normalised, or hardened and tempered, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.30 and not more than 0.45 per cent.
Silicon	not less than 0.10 and not more than 0.35 per cent.
Manganese	not more than 1.50 per cent.
Nickel	not less than 0.90 and not more than 1.00 per cent.
Sulphur	not more than 0.05 per cent.
Phosphorus	not more than 0.05 per cent.

Condition of material on delivery (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

a. Material required in the hardened and tempered condition.

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

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

b. Material required in the normalised condition.

Normalise at a temperature between 830°C. and 860°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	Normalised 6 in.	Q (H & T) 6 in.
Ultimate tensile stress, tons per sq. in.	not less than 35	40
Yield stress, tons per sq. in.	not less than 20	30
Elongation, per cent	not less than 20	22
Izod impact value, ft. lb. Up to and including 4 in. ruling section	not less than 20	35
Over 4 in. up to and including 6 in. ruling section	not less than 15	25
Brinell hardness number	152/207	179/229

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

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 tons per sq. in. min.

Chemical composition. The steel shall contain :

Carbon	not less than 0.15 and not more than 0.25 per cent.
Silicon	not less than 0.10 and not more than 0.35 per cent.
Manganese	not less than 1.40 and not more than 1.80 per cent.
Nickel	not less than 0.40 and not more than 0.70 per cent.
Molybdenum	not less than 0.15 and not more than 0.35 per cent.
Sulphur	not more than 0.05 per cent.
Phosphorus	not more than 0.05 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, 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 :

Limiting ruling section	6 in.
Ultimate tensile stress, tons per sq. in.	not less than 40
Yield stress, tons per sq. in.	not less than 30
Elongation, per cent	not less than 22
Izod impact value, ft. lb.	not less than 40
Brinell hardness number	179/229

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

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 per sq. in. according to the ruling section of the part.

The purchaser should state on the order for which condition, normalised, or hardened and tempered, Q or R, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.15 and not more than 0.25 per cent.
Silicon	not less than 0.10 and not more than 0.35 per cent.
Manganese	not less than 1.30 and not more than 1.70 per cent.
Nickel	not more than 0.40 per cent.
Chromium	not more than 0.25 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

a. Material required in the hardened and tempered condition.

Harden in oil or water from a temperature of 840°/900°C.

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

b. Material required in the normalised condition.

Normalise at a temperature between 840°C. and 900°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	Q	R
	(H. & T.)	(H. & T.)	(H. & T.)
Limiting ruling section	6 in.	4 in.	1 1/2 in.
Ultimate tensile stress,			
tons per sq. in.	not less than	40	45
Yield stress, tons per sq. in. not less than	21	28	30
Elongation, per cent	not less than	20	20
Izod impact value, ft. lb. not less than	—	30	25
Brinell hardness number	152/207	179/229	201/255

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

NOTE. If bright bars are required against specific mechanical properties in the cold worked condition these should be as follows :

Limiting ruling section	2 in.
Ultimate tensile stress,	
tons per sq. in.	not less than 45
Yield stress, tons per sq. in.	not less than 30
Elongation, per cent	not less than 15
Izod impact value, ft. lb.	not less than 15

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 per sq. in. according to the ruling section of the part.

The purchaser should state on the order for which condition, normalised, or hardened and tempered, Q or R, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.20 and not more than 0.30 per cent.
Silicon	not less than 0.10 and not more than 0.35 per cent.
Manganese	not less than 1.30 and not more than 1.70 per cent.
Nickel	not more than 0.40 per cent.
Sulphur	not more than 0.06 per cent.
Phosphorus	not more than 0.06 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

- 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.
- Material required in the normalised condition. Normalise at a temperature between 840°C. and 880°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 6 in.	Q (H. & T.) 4 in.	R (H. & T.) 2½ in.
Limiting ruling section			
Ultimate tensile stress, tons per sq. in.	38	40	45
Yield stress, tons per sq. in. <i>not less than</i>	23	28	30
Elongation, per cent	20	20	20
Izod impact value, ft. lb. <i>not less than</i>	—	35	30
Brinell hardness number	179/229	179/229	201/255

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

NOTE. If bright bars are required against specific mechanical properties in the cold worked condition these should be as follows :

Limiting ruling section	2 in.
Ultimate tensile stress, tons per sq. in.	<i>not less than</i> 45
Yield stress, tons per sq. in.	<i>not less than</i> 30
Elongation, per cent	<i>not less than</i> 15
Izod impact value, ft. lb.	<i>not less than</i> 15

CARBON-MANGANESE STEEL (HIGHER TENSILE)

BAR3 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 per sq. in. according to the ruling section of the part.

The purchaser should state on the order for which condition, Q, R or S, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than 0.30 and not more than 0.40 per cent.
Silicon	not less than 0.10 and not more than 0.35 per cent.
Manganese	not less than 1.30 and not more than 1.70 per cent.
Sulphur	not more than 0.05 per cent.
Phosphorus	not more than 0.05 per cent.

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

Harden in oil 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 :

	Q 6 in.	R 2½ in.	S ¾ in.
Limiting ruling section			
Ultimate tensile stress, tons per sq. in.	40	45	50
Yield stress, tons per sq. in. <i>not less than</i>	28	34	38
Elongation, per cent	22	20	20
Izod impact value, ft. lb. <i>not less than</i>	35*	30	30
Brinell hardness number	179/229	201/255	223/277

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

* This figure shall be reduced to 25 ft. lb. for ruling sections over 4 in.

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 per sq. in. according to the ruling section of the part. The purchaser should state on the order for which condition, Q, R or S, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than	0.30	and not more than	0.40	per cent.
Silicon	not less than	0.05	and not more than	0.35	per cent.
Manganese	not less than	1.30	and not more than	1.70	per cent.
Sulphur	not more than	0.06	per cent.		
Phosphorus	not more than	0.06	per cent.		

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forging and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

Harden in oil 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 :

	Q	R	S
Limiting ruling section	4 in.	2½ in.	¾ in.
Ultimate tensile stress, tons per sq. in.	not less than 40	45	50
Yield stress, tons per sq. in.	not less than 26	32	36
Elongation, per cent	not less than 20	20	20
Izod impact value, ft. lb.	not less than 25	25	25
Brinell hardness number	179/229	201/255	223/277

Mass effect. The above indicates the limiting sizes of ruling section for which the properties can be guaranteed.

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 per sq. in. according to the ruling section of the part. The purchaser should state on the order for which condition, Q, R, S, or T, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than	0.35	and not more than	0.40	per cent.
Silicon	not less than	0.05	and not more than	0.35	per cent.
Manganese	not less than	1.10	and not more than	1.30	per cent.
Sulphur	not more than	0.06	per cent.		
Phosphorus	not more than	0.06	per cent.		

Condition of material on delivery. (i) Bars and billets for forgings shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars selected as stated in clause 6, page 14, and to material supplied in the finally heat treated condition, shall be as follows :

Harden in oil 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 :

	Q	R	S	T
Limiting ruling section	4 in.	2½ in.	¾ in.	¾ in.
Ultimate tensile stress, tons per sq. in.	not less than 40	45	50	55
Yield stress, tons per sq. in.	not less than 26	32	36	42
Elongation, per cent	not less than 20	20	20	18
Izod impact value, ft. lb.	not less than 25	25	25	25
Brinell hardness number	179/229	201/255	223/277	248/302

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

MANGANESE-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) and 65/75(V) tons per sq. in., according to the ruling section of the part.

The purchaser should state on the order for which condition, R, S, T, U or V, the material is required.

Chemical composition. The steel shall contain :

Carbon	not less than	0.25	and not more than	0.40	per cent.
Silicon	not less than	0.10	and not more than	0.35	per cent.
Manganese	not less than	1.30	and not more than	1.80	per cent.
Molybdenum	not less than	0.20	and not more than	0.35	per cent.
Sulphur	not more than	0.05	per cent.		
Phosphorus	not more than	0.05	per cent.		

Condition of material on delivery. (i) Bars and billets for forging shall be delivered as rolled or forged, unless the order states otherwise (see clause 7, page 16).

(ii) Forgings and drop-forgings shall be delivered in the finally heat treated condition, unless the order states otherwise (see clause 7, page 16).

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

(iv) 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 the test bars, selected as stated in clause 6, page 14, 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.

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

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	R. 6 in.	S. 4 in.	T. 2½ in.	U. 1½ in.	V. ¾ in.
Ultimate tensile stress, tons per sq. in. not less than	45	50	55	60	65
Yield stress, tons per sq. in., not less than	34	38	44	48	52
Elongation, per cent, not less than	22	20	18	17	16
Izod impact value, ft. lb., not less than	40	40	40	35	35
Brinell hardness number	201/255	223/277	248/302	269/321	293/341

Mass effect. The above indicates the limiting sizes of ruling section for which the properties stated can be guaranteed.

Steels for special applications. For special applications the steel may be ordered to specification En. 16A, En. 16B or En. 16C, when it will be supplied to a specified composition only, the limits of which are shown in table 5, page 136.

Mechanical properties are not part of the contractual obligations of specifications En. 16A, En. 16B, and En. 16C.