BS 970 :
Part 1 : 1991

Reprinted, incorporating
Amendment No. 1

Specification for

Wrought steels for mechanical and allied engineering purposes

Part 1. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels

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

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

BSi
British Standards

Committees responsible for this British Standard

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

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Specification for wrought steels for mechanical and allied engineering purposes
Part 1. General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels

Revised text

Foreword

Delete paragraph 5 and substitute the following.

The European requirements for stainless steels are specified in BS EN 10088-1, BS EN 10088-2 and BS EN 10088-3, which are the English language versions of EN 10088-1, EN 10088-2 and EN 10088-3, and are published simultaneously with this amendment. These standards which are applicable to stainless steels in all product forms previously covered by this standard, except forgings, should be used in preference to this standard whenever applicable.

Work is continuing in Europe to prepare standards covering boron steels and surface quality.

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Contents

Foreword

This Part of BS 970 has been prepared under the direction of the Iron and Steel Standards Policy Committee and is identical with BS 970 : Part 1 : 1983 except for the deletion of requirements for quenched and tempered steels and steels for bright bar. This standard, together with BS EN 10083-1, BS EN 10083-2 and BS 970 : Part 3 supersedes BS 970 : Part 1 : 1983, which is withdrawn. This edition introduces technical changes but it does not reflect a full review or revision of the standard, which will be undertaken in due course.

Appendix D of BS 970 : Part 1 : 1983 is not included in this new edition as it no longer reflects the current situation on steel grades.

The European requirements for quenched and tempered steels are specified in BS EN 10083-1 and BS EN 10083-2 which are the English language versions of EN 10083-1 and EN 10083-2 and are published simultaneously with this British Standard.

Requirements for steels for bright bar are given in BS 970 : Part 3 : 1991 which is published simultaneously with this standard.

Work is continuing in Europe to prepare standards covering stainless steels, boron steels and surface quality.

As the European Standards are published, the appropriate tables and text will be deleted from BS 970 : Part 1 : 1991 until it is eventually withdrawn.

This edition of BS 970 : Part 1 still specifies Izod impact values for steels. It should be noted, however, that the Izod test is not accepted in Europe and that only the Charpy impact test will be specified in European Standards.

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

Section one. General inspection and testing procedure

1.1 Scope

Section one of this Part of BS 970 specifies the requirements for steelmaking and general testing and inspection procedures for the release of steel in the form of blooms, billets, slabs, bars, rods and forgings, used in the as-rolled, as-forged or softened condition as appropriate and in accordance with the specific requirements for the steels in sections two to five inclusive.

NOTE 1. Forgings above 150 mm ruling section in carbon and alloy steels may be ordered in accordance with BS 29 and BS 4670 respectively and released to the requirements of those standards.

NOTE 2. Particular attention is also drawn to the information given in the foreword.

Sections two to five cover specific requirements for the supply of steels as follows:

Section two	As-rolled and as-rolled and softened steels and micro-alloyed carbon manganese steels
Section three	Through hardening boron steels
Section four	Case hardening steels
Section five	Stainless and heat resisting steels
Section six	Specifies sizes and tolerances.

NOTE 3. The titles of the publications referred to in this standard are listed on the inside back cover.

1.2 Definitions

For the purposes of this Part of BS 970 the definitions given in **1.4.4.1** and **1.13.1** apply.

1.3 Symbols

The symbols used in this standard are given in **1.3.1** to **1.3.4.**

1.3.1 Tensile properties

R_m	denotes tensile strength
R_e	denotes yield strength
A	denotes percentage elongation after fracture
S_o	denotes original cross-sectional area of the gauge length
$R_{p0.2}$	denotes 0.2 % proof stress (non proportional elongation)
$R_{p1.0}$	denotes 1.0 % proof stress (non proportional elongation)
$R_{t0.5}$	denotes 0.5 % proof stress (total elongation)
$R_{t1.0}$	denotes 1.0 % proof stress (total elongation)
R_{eH}	denotes upper yield stress

1.3.2 Impact properties

KCV	denotes Charpy V-notch impact value

1.3.3 Hardness

HB	denotes Brinell hardness
HV	denotes Vickers hardness
HRC	denotes Rockwell hardness (C scale)

1.3.4 Other

LRS	denotes limiting ruling section

1.4 General

1.4.1 Quality. The steel shall be selected and ordered by the purchaser and shall be supplied in accordance with the appropriate general requirements specified in this section and with the specific material requirements specified in sections two to five inclusive (but see also note to **1.7.1**) and with the tolerances specified in section six. The manufacturer shall be responsible to the purchaser with respect to the compliance of the steel with these requirements and any additional requirements specified by the purchaser. All these requirements shall apply equally to steels given in categories 1 and 2.

NOTE. When category 1 and category 2 steels are available, selection should be made from category 1 whenever possible (see also foreword). To facilitate this selection, category 1 steels are printed throughout the standard in normal (upright) type, and category 2 steels in italic (sloping) type.

1.4.2 Supply options. Where appropriate, the specific requirements of sections two to five cover supply options as follows.

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

NOTE. For special applications, e.g. induction hardening, these steels may also be supplied with mechanical properties or hardenability specified by agreement between the purchaser and the supplier.

(b) To a combination of mechanical properties (M grades) or hardenability requirements (H grades) and chemical composition.

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

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

1.4.4 Ruling section and hardenability

1.4.4.1 *Definitions*

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

1.4.4.1.2 limiting ruling section. For any composition of steel, the limiting ruling section is the largest diameter in which certain specified mechanical properties are achieved after a specified heat treatment.

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

NOTE. Further information is given in BS 5046.

1.4.4.2 *Mechanical properties*

1.4.4.2.1 For carbon and carbon manganese case-hardening steels, it is customary to test and release steel to specified mechanical property levels using a standard size of test bar. However, because of the effect of section size, the properties are quoted for different test bar sizes in the oil-quenched conditions, i.e. 13 mm, 19 mm and 29 mm, but the 19 mm size shall be used, except by agreement.

1.4.4.2.2 For alloy and boron case-hardening steels, it is now customary to test and release steel to hardenability requirements. Hardenability bands for these steels (based on BS 4437) are included in section four. These hardenability bands may be used as a guide to estimate the tensile strength of a ruling section at the time of heat treatment. When M steels are ordered, the properties quoted are for a test bar size of 19 mm (see **1.13.3.4.1**).

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

1.5 Information to be supplied by the purchaser

The following information shall be stated on the enquiry and order. Purchasers should pay particular attention to the fact that the standard permits the options shown in the following list and where no specific choice is made by the purchaser, the supplier may select those considered appropriate, excepting that for items (a), (b), (c), (d), (e), (f) and (u) he shall refer the matter to the purchaser.

NOTE. A drawing of the part to be made may be useful in appropriate cases.

(a) The steel selected from **2.1** or **2.2**, section three, section four or section five, or specific requirements for a non-standard steel to be released to the requirements of section one.

(b) The applications of the billets and bars required, e.g. for forging, re-rolling, cold forming, metal coating, induction hardening and welding; the end use, if known, of the material (see **1.9.2**); and whether the component is to be nitrided.

(c) Whether the steel is to be supplied to A, M, or H grade requirements (see **1.4.2**).

(d) If ordered to the requirements of **2.2**, the condition (see table 3).
If ferritic or martensitic steels are ordered to the mechanical property requirements of section five, the ruling section and tensile strength ranges required (see table 13).

(e) If ordered to the hardenability requirements of sections three or four, the hardness values at the required distances (see **1.15.4** and tables 6 and 7).

(f) In the case of carbon steels supplied to composition only which are not required for forgings and drop forgings, whether rimmed, balanced or killed steel is required (see **1.6.3.1** and appendix B).

(g) If a specific steelmaking or casting process is required or, conversely, is not acceptable (see **1.6.1** and **1.6.2**) and, if required, the minimum reduction from the as cast state to the hot worked product (see note to **1.6.2**, **1.9.1.2** and **1.18**).

(h) If a steel having a controlled grain size is required (see **1.6.4**) and the method of measurement if other than method 1 of BS 4490.

(i) The phosphorus and sulphur contents required if different from the standard limits (see **1.7.2**).

(j) If a steel containing lead is required (see **1.7.4**).

(k) Whether there are special requirements with regard to the amount of residual elements and/or what information is required on the certificate (see **1.7.3** and **1.18**).

(l) If any other special quality criteria, e.g. vacuum degassing, ultrasonic testing and cleanness check, are required (see **1.9**).

(m) The condition on delivery in which the material is to be supplied (see **1.10** and tables 5, 9 and 10).

(n) Whether, in the case of billets and bars, the material shall be suitable for cold shearing.

(o) If a maximum decarburization limit is required (see **1.9.2.5**).

(p) In the case of austenitic stainless steels, whether an intercrystalline corrosion test is required (see **1.15.6**).

(q) If a 0.2 % proof stress, and in the case of austenitic steels, and/or a 1.0 % proof stress, is to be determined (see **1.15.1.4**).

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

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

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

(u) Sizes, lengths and tolerances required (see section six).

1.6 Steelmaking and casting process

1.6.1 General. The steelmaking and casting process shall be at the option of the manufacturer unless otherwise specified on the enquiry and order. The air or mixed air and oxygen bottom blown basic converter process is not permitted.

NOTE. *Electric quality* steel is steel melted in an induction furnace or in a basic lined electric arc furnace. When produced in the arc furnace the conventional double slag process is used. The steel is characterized by a high standard of cleanness and by low sulphur and phosphorus contents which can also be achieved by various alternative techniques, e.g. by selection of raw materials and/or secondary steelmaking.

Electrically melted steel is steel made in an electric furnace under conditions not necessarily complying with the requirements for electric quality steel and which complies with standards similar to those required of open hearth steel.

1.6.2 Casting process. The steel shall be cast into ingots or shall be continuously cast unless the purchaser specifies a particular method on the enquiry and order.

NOTE. Material in the as cast condition is not covered by this standard. When specifically required, the purchaser may specify a minimum reduction from the as cast state to the hot worked product (see also **1.9.1.2**).

1.6.3 Deoxidation

1.6.3.1 *Carbon and carbon manganese steels.* Carbon and carbon manganese steels supplied as A grades shall be deoxidized as stated in appendix B. If a choice is available, this shall be at the option of the purchaser and shall be stated on the enquiry and order.
Steels supplied as M or H grades shall be killed unless otherwise agreed and stated on the order.
Steels for case hardening shall be killed. Steels for forgings and drop forgings shall be killed unless otherwise agreed and stated on the order.

1.6.3.2 *Boron and micro-alloyed steels.* Boron and micro-alloyed steels shall be killed.

1.6.3.3 *Alloy and stainless steels.* Alloy and stainless steels shall be killed.

1.6.4 Controlled grain size

1.6.4.1 *Carbon and carbon manganese steels.* If required, many of the steels can be supplied having a controlled grain size of 1 to 5 (coarse grain) or 5 to 8 (fine grain) determined in accordance with the appropriate method of BS 4490.

NOTE 1. Other methods for the determination of grain size may be used by agreement, see also note 1 to **1.6.4.2**.

NOTE 2. Where compliance with a specific impact test is required, fine grain steel will normally be supplied.

1.6.4.2 *Alloy steels.* Alloy steels can be supplied fine grain size controlled, i.e. having a grain size of 5 to 8 determined in accordance with the appropriate method of BS 4490 or another method by agreement. Steels supplied to hardenability requirements are supplied fine-grained and if coarse grain steel is specifically required, then the hardenability shall be subject to negotiation.

NOTE 1. Steel is normally fine-grained if the total aluminium content is > 0.018 %. However, in cases of dispute the appropriate method of BS 4490 should be used.

NOTE 2. Grain sizes finer than 8 may be permitted by agreement.

NOTE 3. Boron steels are supplied with a grain size of 5 or finer. Micro-alloyed steels are not subject to grain size control.

1.6.5 Cleanness. If required, standards for the degree of freedom from non-metallic inclusions and methods of determination shall be agreed between the purchaser and the supplier.

1.7 Chemical composition

1.7.1 Composition ranges. The chemical composition of the steel, based on cast analysis, shall comply with the requirements of the appropriate material specification in sections two to five.

NOTE. Where, in exceptional cases, the purchaser requires a steel of other than standard composition, this should be agreed at the time of the enquiry and order.

1.7.2 Sulphur and phosphorus contents

1.7.2.1 Carbon, carbon manganese and boron steels shall be supplied with sulphur and phosphorus contents each of 0.050 % maximum. For alloy steels, the sulphur content shall be 0.040 % maximum and the phosphorus content 0.035 % maximum.

NOTE. Where specifically ordered, a lower content of sulphur and phosphorus, with each element at 0.025 % maximum, may be supplied. This is recommended for certain alloy nitriding steels (see table 6) and for tensile strength ranges of 1225 N/mm^2 minimum and greater. Other limits for sulphur and phosphorus may be agreed between the purchaser and the supplier and stated on the order.

1.7.2.2 Unless otherwise stated in the material specification, steels can be supplied to the following controlled sulphur ranges, with associated phosphorus contents, which shall be agreed between purchaser and supplier and stated on the order.

Steels	Sulphur	Phosphorus
	%	%
Carbon and carbon manganese steels, and boron steels unless otherwise specified	0.025–0.050 0.015–0.040	0.050 max. 0.025 max.
Alloy steels	0.025–0.050 0.015–0.040	0.035 max. 0.025 max.

NOTE 1. Other ranges can be supplied by agreement between the purchaser and the supplier.

NOTE 2. These ranges should be used when it is considered desirable to minimize the adverse effect which low sulphur content can have on machinability.

1.7.2.3 The sulphur and phosphorus contents for stainless steels are given in tables 10 and 11.

1.7.3 Residual elements

1.7.3.1 Elements not quoted in the relevant specification shall not be added to the steel without the agreement of the purchaser other than for the purpose of finishing the heat or to achieve anticipated or specified properties.

NOTE. If required, the purchaser, by agreement with the manufacturer, may specify a maximum content of one or more residual elements and/or may require the amount of stated elements to be reported on the appropriate certificate.

1.7.3.2 In carbon, carbon manganese, boron and alloy steels, percentages of elements up to the following maxima shall be considered as incidental:

chromium 0.30 %;
molybdenum 0.15 %;
nickel 0.40 %.

1.7.3.3 In micro-alloyed steels, maxima for residual elements shall be agreed between the purchaser and the supplier.

1.7.3.4 In stainless steels, percentages of elements up to the following maxima shall be considered as incidental:

Elements	Non-austenitic steels	Austenitic steels
	%	%
Molybdenum	0.30	1.00
Niobium	–	0.20
Titanium	–	0.10
Copper	0.30	0.70

1.7.4 Steels containing lead. Steels containing lead may be supplied by agreement and the agreed lead range shall be stated on the order. In the absence of this agreement it shall be not less than 0.12 % nor greater than 0.35 % on the product analysis and shall be evenly and finely distributed.

NOTE. If requested by the purchaser, the distribution may be checked by either a lead print, lead exudation test or by ultrasonic methods, the details for which should be agreed between the purchaser and the supplier.

The supplier shall endorse the invoice, delivery document, or appropriate certificate to indicate that lead has been added to comply with the specified requirement, and the steel shall be identifiable by a distinguishing mark agreed between the purchaser and the supplier.

1.8 Product analysis and permitted variations

1.8.1 Analysis of the product may vary from the specified cast analysis due to heterogeneity arising during solidification. Table 1 shows the variations permitted in product analysis in relation to cross sections not greater than 65 000 mm^2.

The table only applies to fully killed steels and not to rimmed or balanced steels. Except in the case of stainless steels, it does not apply to resulphurized free-cutting steel with respect to the elements sulphur and phosphorus.

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

1.8.2 Any product which on subsequent analysis falls outside the permitted variations on the composition range specified for any element, shall be deemed not to comply with the requirements of this standard.

1.8.3 In the event of the results of the analysis of a single sample falling outside the permitted variations on the product analysis, further samples shall be selected for analysis from the remainder of the consignment as follows:

(a) at least two samples from the same cast for delivered masses up to 5 t;

(b) at least five samples from the same cast for delivered masses up to 20 t;

(c) at least eight samples from the same cast for delivered masses over 20 t.

The results of the analysis of these samples shall fall within the permitted variations. If any of these further samples are proved to be outside the permitted variations for any specified element, the consignment shall be deemed not to comply with the requirements of this standard.

1.8.4 Samples for product analysis shall be taken in accordance with BS 1837 and in the event of dispute analysed in accordance with the appropriate methods of British Standard Handbook No. 19.

1.9 Freedom from defects

1.9.1 General

1.9.1.1 Special testing and inspection arrangements may, if required, be agreed between the purchaser and the supplier and should be stated at the time of enquiry and order.

1.9.1.2 The procedures for casting, working, reheating and cooling and the amount of working shall ensure that the product is free from piping, central unsoundness, harmful segregation and other harmful internal and external defects.

1.9.2 Surface defects

1.9.2.1 Products intended for applications such as hot forgings which are not required for subsequent overall machining (see **1.9.2.2**) shall have a high standard of surface quality and the surface conditioning shall be such as to remove defects detrimental to the appropriate processing and, where specified, the end use.

Products intended for applications such as upset forging, cold heading or cold forging may require a higher degree of freedom from surface imperfection which shall be agreed between the purchaser and the supplier.

1.9.2.2 Products intended for subsequent overall machining need not have the same freedom from surface defects as specified in **1.9.2.1**. Surface conditioning need only be such as to remove harmful defects having regard to the machining allowance.

The machining allowance shall not be less than 2 % on depth on the minimum permissible diameter of rounds or 2 % per side on the minimum permissible dimensions of flats or other solid sections.

NOTE. Machining allowances less than these may be agreed between the purchaser and the supplier.

1.9.2.3 Products for rerolling or for applications other than those covered by **1.9.2.1** and **1.9.2.2** shall be free from defects harmful to their appropriate processing and, where specified, the end use. Material supplied to these conditions may not be suitable for the applications covered by **1.9.2.1** and **1.9.2.2.**

1.9.2.4 Forgings and drop forgings shall be finished in a workmanlike manner and shall be free from flaws and harmful defects.

1.9.2.5 When required, maximum decarburization levels shall be agreed between the purchaser and the supplier.

NOTE. The surfaces of bars for induction hardening may be required to be free from decarburization and they will usually be turned or ground. If supplied in the black condition, overall grinding or turning may be permitted to clear decarburization, if necessary.

1.10 Condition of material on delivery

1.10.1 Carbon, carbon manganese, boron, micro-alloyed and alloy steels

1.10.1.1 *Blooms, billets, slabs, black bars and rods.* Blooms billets, slabs, black bars and rods shall be supplied as rolled or as forged unless otherwise agreed between purchaser and supplier and stated on the order.

1.10.1.2 *Forgings and drop forgings.* Forgings and drop forgings shall be supplied in the condition stated on the order.

1.10.1.3 *Normalized bars.* Normalized bars shall be supplied to the specified mechanical properties and in the condition stated on the order.

1.10.1.4 *Material used in non heat treated condition.* Material to be used in the non heat treated condition may

Table 1. Permitted variations of product analysis from specified range

Element	Range in which maximum of specified element falls	Variation on specified range	
		Over max.	Under min.
	%	%	%
(a) *Carbon, carbon manganese, boron and micro-alloyed steels*			
Carbon*	⩽ 0.25	0.02	0.02
	> 0.25 ⩽ 0.50*	0.03	0.03
	> 0.50 ⩽ 1.05	0.04	0.04
Silicon	⩽ 0.40	0.03	0.03
Manganese	⩽ 1.0	0.04	0.04
	> 1.0 ⩽ 1.5	0.08	0.08
	> 1.5	0.10	0.10
Phosphorus	⩽ 0.025	0.005	
	> 0.025 ⩽ 0.040	0.006	
	> 0.040 ⩽ 0.060	0.008	
Sulphur	⩽ 0.025	0.005	
	> 0.025 ⩽ 0.040	0.006	
	> 0.040 ⩽ 0.060	0.008	
	> 0.060 ⩽ 0.10	0.010	
	When range is specified:		
	0.015–0.040	0.006	0.003
	0.025–0.050	0.008	0.005
	0.050–0.10	0.010	0.008
(b) *Alloy steels*			
Carbon	⩽ 0.25	0.01	0.01
	> 0.25 ⩽ 0.50	0.02	0.02
	> 0.50	0.03	0.03
Silicon	⩽ 0.45	0.03	0.03
Manganese	⩽ 0.70	0.03	0.03
	> 0.70 ⩽ 1.0	0.04	0.04
	> 1.0 ⩽ 2.0	0.05	0.05
Phosphorus	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.040	0.004	
Sulphur†	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.040	0.004	
	> 0.040 ⩽ 0.050	0.005	
	When range is specified:		
	0.015–0.040	0.004	0.003
	0.025–0.050	0.005	0.003
Chromium	⩽ 0.60	0.03	0.03
	> 0.60 ⩽ 1.25	0.04	0.04
	> 1.25 ⩽ 2.50	0.05	0.05
	> 2.50 ⩽ 4.0	0.10	0.10
Molybdenum	⩽ 0.50	0.02	0.02
	> 0.50	0.03	0.03

Element	Range in which maximum of specified element falls	Variation on specified range	
		Over max.	Under min.
	%	%	%
Nickel	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 3.0	0.05	0.05
	> 3.0 ⩽ 5.0	0.07	0.07
Aluminium	> 0.80 ⩽ 1.50	0.10	0.10
Vanadium	⩽ 0.30	0.03	0.03
(c) *Stainless and heat resisting steels*			
Carbon	⩽ 0.03	0.005	
	> 0.03 ⩽ 0.25	0.01	0.01
	> 0.25 ⩽ 0.50	0.02	0.02
Silicon	⩽ 1.0	0.05	0.05
	> 1.0 ⩽ 2.0	0.07	0.07
Manganese	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 2.0	0.04	0.04
Phosphorus	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.045	0.004	
	> 0.045	0.005	
Sulphur	⩽ 0.030	0.003	
	> 0.030 ⩽ 0.080	0.005	
	Specified range		
	0.15–0.35	0.02	0.02
Chromium	⩽ 10.0	0.10	0.10
	> 10.0 ⩽ 15.0	0.15	0.15
	> 15.0 ⩽ 20.0	0.20	0.20
	> 20.0	0.25	0.25
Molybdenum	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 2.0	0.05	0.05
	> 2.0 ⩽ 3.0	0.08	0.08
Nickel	⩽ 1.0	0.03	0.03
	> 1.0 ⩽ 3.0	0.05	0.05
	> 3.0 ⩽ 5.0	0.07	0.07
	> 5.0 ⩽ 10.0	0.10	0.10
	> 10.0 ⩽ 20.0	0.15	0.15
	> 20.0	0.20	0.20
Niobium	All ranges	0.05	0.05
Selenium	All ranges	0.03	0.03
Titanium	All ranges	0.05	0.05

*When required by the purchaser and subject to agreement with the supplier, smaller variations for the carbon range over 0.25 % up to and including 0.50 % may be agreed.

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

be supplied to Brinell hardness values, by agreement between the purchaser and the supplier.

1.10.2 Stainless steels

1.10.2.1 *Ferritic steels.* Products in ferritic steels shall be supplied in the softened condition.

1.10.2.2 *Martensitic steels*

1.10.2.2.1 Products for subsequent hot working shall be supplied in the softened condition.

1.10.2.2.2 Forgings, drop forgings and bars for machining shall be supplied in the condition stated on the order.

1.10.2.3 *Austenitic steels*

1.10.2.3.1 Products for subsequent hot working shall normally be supplied in the as forged or as rolled condition.

1.10.2.3.2 Forgings, drop forgings and bars for machining shall be supplied in the softened condition and, if required, subsequently descaled. The softening treatment may be omitted if free cooling of the product from hot working does not lead to the formation of carbide precipitates or sigma or other detrimental phases and if it complies with the requirements for the mechanical and intercrystalline corrosion tests.

1.11 Heat treatment

The heat treatment to be given to the test bars and to material required in the finally heat treated condition shall be as specified in tables 5, 9, 10 and 11.

1.12 Mechanical properties

In the material specifications included in this standard, all the specified mechanical properties refer to tests taken in the longitudinal direction (see **1.13.3.3** and **1.13.4.2**).

1.13 Selection and preparation of material for mechanical testing (not applicable to micro-alloyed steels*)

1.13.1 Definitions

1.13.1.1 test sample. The portion of the material selected for testing.

1.13.1.2 test bar. The test sample after preparation for heat treatment.

1.13.1.3 test piece. The test sample or test bar as finally prepared for testing.

1.13.2 Tensile strength of 1225 N/mm^2 or greater. Where the tensile strength of alloy steel is specified as 1225 N/mm^2 minimum or more, the test bar may be machined to test piece size, plus a grinding allowance if required, before heat treatment. In such cases, the properties obtained are representative of those parts heat treated in the same ruling section as that of the test piece and may not represent larger ruling sections.

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

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

Subject to the requirements of **1.4.1**, one tensile test and, where relevant, one Izod impact test, comprising three notches, or three Charpy V-notch impact tests shall be taken from any batch of material of similar ruling section from the same cast. For the purpose of subsequent orders, these tests shall be taken as representing all sizes of material from the same cast where the ruling section of the forgings or parts does not exceed the ruling section of the test bar already tested.

1.13.3.2 *Bars for machining supplied in the finally heat treated condition.* The samples shall be cut from the heat treated bars and shall not be further heat treated or mechanically worked after their removal.

Subject to the requirements of **1.4.1**, one tensile test and, where relevant, one Izod impact test, comprising three notches, or three Charpy V-notch impact tests shall be made on any batch of bars of similar size from the same cast and heat treated together, when applicable.

1.13.3.3 *Forgings, drop forgings and machined parts.* For forgings and drop forgings with a ruling section equivalent to a diameter greater than 29 mm, integral test samples may be provided by agreement between the purchaser and the supplier, when a prolongation shall be provided on an agreed proportion of forgings or drop forgings. Unless otherwise agreed, the prolongation shall have a diameter approximately equal to the ruling section of the forging or drop forging at the time of heat treatment and it shall not be finally severed until after heat treatment.

Where integral test samples are not practicable or are not required, for small forgings and drop forgings with ruling sections equivalent to a diameter of 29 mm or less, and for parts machined from bars not finally heat treated, separate test samples shall be provided. These shall be provided from the bars or billets from which the forgings, drop forgings or parts are made, or may be additional forgings, drop forgings or parts. The test samples shall be forged and/or machined to test bars of a diameter, or equivalent diameter, corresponding to the ruling section of the forgings, drop forgings or parts and shall be heat treated with the material they represent. The number of tests shall be agreed between the purchaser and the supplier.

Where integral test samples are required and it is not practicable to take tests in a longitudinal direction, tests may be taken in an alternative direction and the properties obtained shall be subject to agreement between the purchaser and the supplier (see **1.13.4.2**).

1.13.3.4 *Steels for case hardening*

1.13.3.4.1 *Size of test bar.* The test bar size shall be 19 mm diameter.

* For micro-alloyed steels, the sampling and test procedure is by agreement (see **2.3**).

NOTE 1. For carbon and carbon manganese steels, 13 mm or 29 mm diameter test bar may be used by agreement (see **1.4.4.2.2**).

NOTE 2. For alloy steels with a tensile strength of 1225 N/mm^2 or greater, see **1.13.2.**

1.13.3.4.2 *Selection of samples.* Subject to the requirements of **1.4.1**, one test sample shall be selected to represent each cast. If the size of the test sample is greater than the specified test bar size, test bars shall be prepared by forging and/or machining to that size; but for sizes smaller than 13 mm diameter, for carbon and carbon manganese steels and for sizes smaller than 19 mm diameter for alloy steels, the test bar shall be heat treated in the full section of the sample.

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

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

1.13.3.4.3 *Heat treatment of test bars.* The test bars shall be blank carburized for at least 1 h at a temperature between 880 °C and 930 °C. After cooling to room temperature, they shall be reheated to the single quenching temperature, as stated in table 9, and quenched in oil.

1.13.4 Location of test pieces for mechanical testing

1.13.4.1 *General.* In the general case where longitudinal tests are required, the test piece shall be prepared in accordance with the following.

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

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

1.13.4.2 *Transverse and other tests.* When transverse tests or tests in other directions are required, the location of the test pieces and values for mechanical properties shall be agreed between the purchaser and the supplier.

1.14 Frequency of other tests

1.14.1 Number of hardness tests. The manufacturer shall carry out sufficient tests in accordance with the relevant clauses of this standard in order to ensure that the material complies with the specified hardness.

1.14.2 Number of hardenability tests. Subject to the requirements of **1.4.1**, unless otherwise agreed, one test sample selected to represent each cast shall be reduced by forging or rolling to a size not greater than 38 mm diameter which shall represent the full cross section of the material. This test bar shall also be of sufficient size to ensure the complete removal of carburization in machining to the standard test piece of 25 mm diameter.

1.14.3 Number of grain size tests. Subject to the requirements of **1.4.1**, when a grain controlled steel is required and unless otherwise agreed, one test sample for the determination of austenitic grain size shall be selected to represent each cast.

1.14.4 Number of intercrystalline corrosion tests (applicable to austenitic stainless steels only). If specified and agreed at the time of enquiry and order, one intercrystalline corrosion test shall be carried out per cast per heat treatment batch on the product having the largest equivalent diameter in the batch.

1.15 Test methods and test results

1.15.1 Tensile test

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

1.15.1.2 In cases of dispute and except as provided in **1.15.1.3**, tensile test pieces shall be machined from blooms, billets, slabs, bars, forgings and drop forgings to the dimensions of the 11.28 mm diameter (100 mm^2 cross-sectional area) test piece or, if the test bar is too small, to the dimensions of the largest recommended round test piece that can be obtained having a gauge length equal to $5.65\sqrt{S_o}$.

1.15.1.3 When agreed between the purchaser and the supplier or for material not greater than 15 mm diameter or width across flats, unmachined test pieces having a gauge length equal to $5.65\sqrt{S_o}$ may be used.

1.15.1.4 The properties specified in the relevant material specification or on the order shall be determined and the results obtained shall comply with the requirements.

For the yield strength R_e of non-austenitic steels, the following properties shall be determined for acceptance purposes unless otherwise agreed. Either the upper yield stress, R_{eH}, or the 0.5% proof stress (total elongation), $R_{t0.5}$, may be determined and the material specification is complied with in this respect if either value satisfies the value of the yield strength R_e. In cases of dispute, the 0.5% proof stress (total elongation), $R_{t0.5}$, shall be determined.

When specifically ordered and permitted by the material specification, the 0.2 % proof stress (non-proportional elongation), $R_{p0.2}$ of non-austenitic steels shall be measured and the value obtained shall comply with the specified requirement.

For austenitic steels, when specifically ordered the 0.2 % proof stress, $R_{p0.2}$, and/or the 1.0 % proof stress $R_{p1.0}$, shall be measured and the value obtained shall comply with the specified requirements. The 1 % proof stress may only be ordered when permitted by the material specified.

1.15.2 Impact tests. Either one or other of the following tests shall be carried out. The choice shall be the option of the supplier.

(a) *Charpy V-notch impact test.* This test shall be carried out in accordance with BS EN 10045-1.

(b) *Izod impact test.* This test shall be carried out in accordance with BS 131 : Part 1.

The average value of the results obtained for three notches shall comply with the relevant requirements of the material specification. One individual value may be below the specified value, provided it is not less than 70 % of that value.

NOTE. It is not possible to convert values from type of impact test to the other.

1.15.3 Hardness test. The Brinell hardness test shall be carried out in accordance with BS 240 using, where possible, a 10 mm diameter ball and load of 3000 kg. Alternatively, Vickers and Rockwell methods of hardness

testing in accordance with BS 427 and BS 891, respectively, may be used.

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

1.15.4 Hardenability test. Hardenability tests shall be carried out in accordance with the appropriate method of BS 4437. The values to be verified shall be selected by the purchaser in accordance with that standard.

NOTE. Graphs for the comparison of the various H grades are given in appendix A. These are for guidance only.

1.15.5 Grain size test. Grain size tests shall be carried out in accordance with the appropriate method given in BS 4490.

NOTE. Other methods may be used by agreement between the purchaser and the supplier, see **1.6.4.**

1.15.6 Intercrystalline corrosion test (applicable to austenitic stainless steels only). A bend test piece shall be prepared and tested in accordance with BS 5903. It shall be sensitized by heating at a temperature of 650 °C for the time specified in table 11 followed by cooling in still air.

1.16 Retests

1.16.1 General. Subject to the requirements of **1.4.1**, retests shall be carried out as specified in **1.16.2** to **1.16.6.** However, if any test sample or test piece fails to comply with the requirements of **1.15** as a result of incorrect test procedure or faulty equipment, the test results shall be discarded and a further test sample(s) shall be retested in accordance with **1.15.**

1.16.2 Tensile tests

1.16.2.1 Should any of the original test pieces fail, twice the original number of test samples shall be selected for retesting, one of which shall be taken from the bar, billet, forging or drop forging from which the original test sample was taken, unless that item has been withdrawn by the manufacturer.

1.16.2.2 The mechanical properties obtained from the test pieces prepared from the further test samples shall comply with the specified requirements. Should any of the retests fail, the material represented shall be deemed not to comply with the requirements of this standard.

1.16.2.3 In the case of material supplied in the heat treated condition, the manufacturer shall have the right to reheat treat the material and resubmit it for testing.

1.16.3 Charpy V-notch impact and Izod impact tests

1.16.3.1 If the average of three impact values is lower than the specified value, or if any one value is lower than 70 % of this specified value, three additional test pieces shall be taken from the same sample and tested. The average value of the six tests shall be not less than the specified value. Not more than two of the individual values may be lower than the specified value and not more than one may be lower than 70 % of this value.

1.16.3.2 In the case of material supplied in the heat treated condition, the manufacturer shall have the right to reheat treat the material and resubmit it for testing.

1.16.4 Hardness test

1.16.4.1 Should the hardness value determined on any bloom, billet, slab, bar, forging, drop forging or machined part fail to comply with the specified requirements, then an adequate number of items shall be selected for retesting, one of which shall be the original bloom, billet, slab, bar, forging, drop forging or machined part, unless that item has been withdrawn by the manufacturer.

1.16.4.2 Should the hardness results obtained on all the retest items comply with specification requirements, then the batch shall be deemed to comply with this standard.

1.16.4.3 Should any retest item exhibit hardness values not complying with the specified requirements, then tensile test pieces may be prepared, as applicable, from the items showing the widest deviation, above and/or below the agreed hardness range. Should the results obtained from such tensile test pieces comply with the tensile test requirements of the specification, then the material shall be deemed to comply with this standard.

Failing this, the batch represented by the original tests may be reheat treated and resubmitted for testing.

1.16.5 Hardenability and grain size tests. Should the results of either of these tests fail to comply with the specified requirements and this is confirmed on retesting, the material shall be deemed not to comply with this standard.

1.16.6 Intercrystalline corrosion test. The relevant provisions of BS 5903 shall apply.

1.17 Inspection

The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the order. He shall be at liberty to inspect the manufacture at any stage and to witness the required tests. When the material is to be inspected and tested in the presence of the purchaser's representative, it shall be so stated on the enquiry and order.

1.18 Manufacturer's statement

If required by the order, the manufacturer shall supply a certificate stating the cast analysis of the material, the heat treatment, the results of the mechanical or other tests, or any combinations of these.

The document supplied shall state the steelmaking and casting process and, when requested, the reduction from the as cast state (see **1.6.1** and **1.6.2**).

1.19 Marking

If the purchaser requires special marking to be applied to the material then the manner of marking shall be the subject of agreement between the purchaser and the supplier. If this marking is required it shall be stated on the enquiry and order (see also **1.7.4** regarding the marking of lead containing steels).

Section two. Specific requirements for as-rolled, as-rolled and softened and micro-alloyed carbon manganese steels

2.1 Specific requirements for as-rolled and as-rolled and softened steels

NOTE. For requirements for through hardening steels, see section three.

Category 1 steels shall be used for new designs and for established designs whenever possible.

The chemical composition and mechanical properties shall be as given in table 2.

2.2 Specific requirements for micro-alloyed carbon manganese steels

NOTE 1. The steels included in this subclause develop their properties by the addition of small amounts of vanadium or other micro-alloying elements, together with control of hot working temperature and subsequent air cooling* and in the finished condition have a ferrite/pearlite structure, free from bainite. They offer, for certain applications, an alternative route to obtaining hardness and tensile strength normally associated with medium carbon and alloy steels in the hardened and tempered condition.

Since the analysis of the steel necessary to attain the specified properties depends on processing conditions and section size, it is not possible to state specific analysis requirements; the analysis, however, shall be selected from within the broad range given in table 3, according to the particular end conditions and strength grade required. In order to be free from bainite, due account shall be taken of those elements which may form this constituent, e.g. Mo, Mn, Cr, Ni and Cu. When necessary, metallurgical advice shall be sought.

NOTE 2. To aid machinability, it may be necessary for the microstructure of the forged part to be agreed.

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

Table 2. As-rolled and as-rolled and softened steels: chemical composition and mechanical property requirements

Steel		Chemical composition			LRS	R_m min.	R_e min.	A min. on	Impact (3)		HB
Category 1(1)	Category 2(1)	C	Mn	Others				5.65 $\sqrt{S_o}$	Izod min.	KCV min.	
Carbon steels (as-rolled)											
		%	%	%	mm	N/mm2(2)	N/mm2(2)		ft·lb	J	
040A04		0.08 max.	0.30-0.50								
040A10		0.08-0.13	0.30-0.50								
040A12		0.10-0.15	0.30-0.50								
080A15		0.13-0.18	0.70-0.90								
080A20		0.18-0.23	0.70-0.90								
055M15		0.20 max.	0.80 max.		150	310	-	25	-	-	121min.
Carbon steels (as-rolled and softened)											
060A62		0.60-0.65	0.50-0.70								207 max.
060A67		0.65-0.70	0.50-0.70								217 max.
080A67		0.65-0.70	0.70-0.90								229 max.
060A72		0.70-0.75	0.50-0.70								241 max.
060A78		0.75-0.82	0.50-0.70								255 max.
060A81		0.78-0.85	0.50-0.70								269 max.

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

(2) 1 N/mm^2 = 1 MPa.

(3) Only applicable if fine grain controlled material is ordered.

Table 3. Micro-alloyed carbon manganese steels: chemical composition and mechanical property requirements

Steel (7)	Chemical composition							Condition (14)	LRS	R_m	R_e min.	A min. on 5.65$\sqrt{S_o}$	Impact KCV min.	HB
	C	Si	Mn	P	S	V	Al							
	%	%	%	%	%	%	%		mm	N/mm^2(2)	N/mm^2(2)		J	
280M01	0.30–0.55	0.15–0.60	0.60–1.50	0.035 max	0.045–0.065 (15)	0.08–0.20 (16)	0.035 max.	S	100	775–925	530	14	10	223–277
								T	100	850–1000	560	12	8	248–302
								U	100	925–1075	600	10	8	269–331

(2) 1 N/mm^2 = 1 MPa.

(7) Category 1 steel.

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

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

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

Section three. Specific requirements for steels for surface hardening by nitriding and for through hardening boron steels

Specific requirements for steels for surface hardening by nitriding shall be as given in table 4.

Specific requirements for through hardening boron steels shall be as given in tables 5 and 6.

Table 4. Steel for surface hardening by nitriding: chemical composition

Steel	Chemical composition				
Alloy steel	C	Mn	Cr	Mo	Others
708M40	0.36 – 0.44	0.70 – 1.00	0.90 – 1.20	0.15 – 0.25	4 X P + Sn ≤0.15 %
709M40	0.36 – 0.44	0.70 – 1.00	0.90 – 1.20	0.25 – 0.35	4 X P + Sn ≤0.15 %
720M32	0.28 – 0.35	0.40 – 0.70	2.80 – 3.30	0.40 – 0.60	
722M24	0.20 – 0.28	0.45 – 0.70	3.00 – 3.50	0.45 – 0.65	4 X P + Sn ≤0.12 %
897M39	0.35 – 0.43	0.45 – 0.70	3.00 – 3.50	0.80 – 1.10	P 0.025 max. S 0.025 max. V 0.15 – 0.25 4 X P + Sn ≤0.10 %
905M39	0.35 – 0.43	0.40 – 0.65	1.40 – 1.80	0.15 – 0.25	P 0.025 max. S 0.025 max. Al 0.90 – 1.30 4 X P + Sn ≤0.10 %

Table 5. Through hardening boron steels: chemical composition and hardenability requirements

Steel		Chemical composition						HRC at distance														
Category 1[1]	Category 2[1]	C	Mn	Cr	Mo	Ni	Others		1.5 mm	3 mm	5 mm	7 mm	9 mm	11 mm	13 mm	15 mm	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm	50 mm
170H20		0.17–0.23	0.80–1.10				Soluble B 0.0005–0.005[18]	max.	48	48	47	46	43	39	32	26	20						
								min.	41	40	36	25											
170H36		0.32–0.39	0.80–1.10				Soluble B 0.0005–0.005[18]	max.	58	58	57	56	54	52	47	41	30	25	24	–	23	–	22
								min.	51	49	47	43	35	26	20								
170H41		0.37–0.44	0.80–1.10				Soluble B 0.0005–0.005[18]	max.	60	60	59	59	58	57	56	55	52	47	40	–	30		
								min.	53	53	52	51	50	47	42	35	28	20					
185H40		0.36–0.45	1.25–1.75	0.15–0.35	0.08–0.18		Soluble B 0.0005–0.005[18]	max.	60	60	60	60	60	60	59	59	59	58	58	57	56	55	54
							S 0.03–0.06	min.	53	53	53	53	52	52	52	51	49	46	43	40	38	36	34

[1] See note to **1.4.1.**

[18] Total boron may be determined providing the hardenability values are realized.

Table 6. Through hardening boron steels: heat treatment requirements

Steel		Heat treatment to be given to test bars and to material required in the finally heat treated condition			Requirements for hardenability test	
Category 1[1]	Category 2[1]	Hardening treatment		Tempering temperature	Preheat treatment temperature	Austenitizing temperature
		Temperature	Quenching medium[24]			
170H20		No mechanical properties specified			910–930	905
170H36					870–890	840
170H41					870–890	840
185H40					870–890	840

[1] See note to **1.4.1.**

[24] O = oil; w = water. Where oil hardening is specified, either a well agitated conventional oil or a proven synthetic quenchant may be used. These synthetic quenchants may be employed at varying levels of dilution with water to achieve different predetermined cooling rates. However, synthetic quenchants shall not be used for the heat treatment of test bars for material not supplied in the finally heat treated condition.'

Section four. Specific requirements for case hardening steels

Tables 7 to 9 bring together requirements for the case hardening steels whether they be carbon or alloy. Additionally, as with some other sections, the steels have been divided into two categories. Category 1 steels should be used for new designs and for established designs whenever this is possible.

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

Attention is drawn to the advantages of specifying hardenability requirements for alloy steels (see table 10).

Table 7. Case hardening boron and alloy steels: chemical composition and hardenability requirements
(for guidance see also appendix A; for mechanical property requirements see table 8)

Steel		Chemical composition						HRC values at distance														
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others		1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
Boron steels (HRC values)																							
		%	%	%	%	%	%		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
170H15		0.12–0.18	0.80–1.10				P 0.060 max. S 0.03–0.06 B 0.0005–0.005	max. min.	45 38	45 38	44 36	43 31	42 25	39 21	36 19	33	27	25	24	–	24		
173H16		0.13–0.19	1.10–1.40				P 0.060 max. S 0.03–0.06 B 0.0005–0.005	max. min.	46 39	46 39	45 38	45 35	44 32	44 28	43 26	42 24	35	32	30	–	28		
174H20		0.17–0.23	1.20–1.50				P 0.060 max. S 0.03–0.06 B 0.0005–0.005	max. min.	48 41	48 41	48 41	48 40	47 39	47 37	47 35	46 32	44 26	42 23	39 21	–	36		
175H23		0.20–0.25	1.30–1.60				P 0.060 max. S 0.03–0.06 B 0.0005–0.005	max. min.	50 43	50 43	50 43	50 43	49 42	49 41	49 39	48 38	46 32	44 27	41 25	– –	39 23		
Alloy steels (HV values)																						
									HV 20 or 30 values at distance													
									1.25	2.00	2.75	3.50	4.25	5.00	5.75	6.50	7.25	9.00	10.5	12.0	15.0	20.0	25.0
523H15		0.12–0.18	0.30–0.60	0.30–0.60				max. min.	510 380	490 340	445 280	385 240	340 200	315 180	295	280	260	235	220	215	210	205	200
527H17		0.14–0.20	0.70–1.00	0.60–0.90				max. min.	460 380	450 365	440 345	415 320	385 295	355 270	330 255	310 250	300 240	285 230	275 220	270 210	270 210	255 190	240

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

Table 7. Case hardening boron and alloy steels: chemical composition and hardenability requirements *(continued)*

Steel		Chemical composition						HRC values at distance																
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others		1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
Alloy steels (HRC values)																								
		%	%	%	%	%	%		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
590H17		0.14–0.20	1.00–1.30	0.80–1.10				max.	47	46	44	42	39	37	34	33	31	30	29	28	27		
								min.	39	36	32	29	26	24	22	20							
	635H15	*0.12–0.18*	*0.60–0.90*	*0.40–0.80*		*0.70–1.10*		*max.*	*45*	*43*	*40*	*36*	*33*	*30*	*28*	*26*	*24*	*23*	*22*	*20*			
								min.	*38*	*32*	*26*	*23*	*21*										
	637H17	*0.14–0.20*	*0.60–0.90*	*0.60–1.00*		*0.85–1.25*		*max.*	*45*	*45*	*44*	*42*	*40*	*37*	*35*	*33*	*31*	*30*	*29*	*28*	*28*	*27*	*26*
								min.	*39*	*37*	*34*	*29*	*27*	*24*	*23*	*21*	*20*						
	655H13	*0.10–0.16*	*0.35–0.60*	*0.70–1.00*		*3.00–3.75*		*max.*	*44*	*44*	*44*	*43*	*42*	*41*	*40*	*39*	*37*	*35*	*34*	*33*	*32*	*32*	*31*
								min.	*37*	*36*	*34*	*32*	*30*	*28*	*27*	*25*	*23*	*22*	*21*				
	665H17	*0.14–0.20*	*0.35–0.75*		*0.20–0.30*	*1.50–2.00*		*max.*	*46*	*44*	*41*	*36*	*31*	*28*	*25*	*24*	*22*	*21*	*20*				
								min.	*39*	*33*	*24*	*21*											
	665H20	*0.17–0.23*	*0.35–0.75*		*0.20–0.30*	*1.50–2.00*		*max.*	*48*	*45*	*41*	*37*	*32*	*29*	*27*	*25*	*23*	*21*	*20*				
								min.	*41*	*35*	*26*	*22*	*20*										
	665H23	*0.20–0.26*	*0.35–0.75*		*0.20–0.30*	*1.50–2.00*		*max.*	*51*	*49*	*46*	*43*	*39*	*34*	*31*	*29*	*27*	*25*	*24*	*23*	*22*	*22*	
								min.	*44*	*40*	*33*	*28*	*26*	*23*	*22*	*21*	*20*						
708H20		0.17–0.23	0.60–0.90	0.85–1.15	0.15–0.25			max.	47	47	46	44	41	39	36	35	33	31	30	29	28	28	
								min.	39	38	35	32	29	26	22	22	20						
	805H17	*0.14–0.20*	*0.60–0.95*	*0.35–0.65*	*0.15–0.25*	*0.35–0.75*		*max.*	*46*	*44*	*40*	*36*	*32*	*28*	*27*	*25*	*23*	*21*	*20*				
								min.	*39*	*33*	*26*	*22*	*20*										
805H20		0.17–0.23	0.60–0.95	0.35–0.65	0.15–0.25	0.35–0.75		max.	48	47	44	40	35	32	30	28	25	24	23	23	23	22	
								min.	41	37	31	25	22	20									

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

Table 7. Case hardening boron and alloy steels: chemical composition and hardenability requirements *(concluded)*

Steel		Chemical composition						HRC values at distance															
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others		1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
Alloy steels (HRC values) *(concluded)*																							
		%	%	%	%	%	%		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
805H22		0.19–0.25	0.60–0.95	0.35–0.65	0.15–0.25	0.35–0.75		max.	50	49	46	43	38	34	32	30	27	25	25	24	24	24	
								min.	43	39	33	28	25	22	20								
808H17		0.14–0.20	0.70–1.05	0.35–0.65	0.30–0.40	0.35–0.75		max.	46	45	44	41	38	34	32	30	28	27	26	26	25	25	
								min.	39	38	33	27	24	23	21	21	19	18					
815H17		0.14–0.20	0.60–0.90	0.80–1.20	0.10–0.20	1.20–1.70		max.	46	46	45	45	44	43	42	41	38	35	34	34	33	33	
								min.	39	37	35	33	32	30	29	27	25	22	20				
820H17		0.14–0.20	0.60–0.90	0.80–1.20	0.10–0.20	1.50–2.00		max.	46	46	46	46	45	45	44	44	42	40	38	38	37	37	
								min.	39	39	38	37	35	33	32	30	28	26	25	25	24	24	
822H17		0.14–0.20	0.40–0.70	1.30–1.70	0.15–0.25	1.75–2.25		max.	46	46	46	46	45	45	45	45	45	44	43	43	42	42	
								min.	39	39	39	38	38	37	37	36	35	33	32	31	30	29	
	832H13	*0.10–0.16*	*0.35–0.60*	*0.70–1.00*	*0.10–0.25*	*3.00–3.75*		*max.*	*44*	*44*	*44*	*44*	*44*	*44*	*44*	*43*	*42*	*40*	*38*	*36*	*35*	*34*	
								min.	*37*	*37*	*37*	*36*	*34*	*32*	*30*	*28*	*26*	*23*	*22*	*21*	*21*	*21*	
835H15		0.12–0.18	0.25–0.50	1.00–1.40	0.15–0.30	3.90–4.30		max.	45	45	45	45	45	45	45	45	45	45	44	44	44	43	
								min.	38	38	38	38	38	38	38	38	37	36	35	34	33	32	

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

Table 8. Case hardening steels: chemical composition and mechanical property requirements

Steel		Chemical composition						Test bar diameter	R_m min.	A min. on $5.65\sqrt{S_o}$	Impact	
Category 1(1)	Category 2(1)	C	Mn	Cr	Mo	Ni	Others				Izod min.	KCV min.
Carbon steels												
		%	%	%	%	%	%	mm	N/mm²(2)		ft·lb	J
045M10		0.07–0.13	0.30–0.60					13	430	18	35	42
								19(28)	430	18	35	42
	045A10	*0.08–0.13*	*0.30–0.60*									
080M15		0.12–0.18	0.60–1.00					13	490	16	30	35
								19(28)	460	16	30	35
								29	430	18	30	35
	080A15	*0.13–0.18*	*0.70–0.90*									
Carbon manganese steels												
130M15		0.12–0.18	1.10–1.50					13	740	13	25	28
								19(28)	650	14	30	35
								29	590	15	35	42
	125A15	*0.13–0.18*	*1.10–1.40*									
210M15		0.12–0.18	0.90–1.30				S 0.10–0.18	13	490	16	30	35
								19(28)	460	16	30	35
								29	430	18	30	35
	210A15	*0.13–0.18*	*0.90–1.20*				*S 0.10–0.18*					
214M15		0.12–0.18	1.20–1.60				S 0.10–0.18	13	740	12	25	28
								19(28)	650	12	30	35
								29	590	13	35	42
	214A15	*0.13–0.18*	*1.20–1.50*				*S 0.10–0.18*					
Alloy steel												
523M15		0.12–0.18	0.30–0.60	0.30–0.60				19	620	13	25	28
527M17		0.14–0.20	0.70–1.00	0.60–0.90				19	770	12	15(29)	16(29)
	527A17	*0.14–0.19*	*0.70–0.90*	*0.70–0.90*								
590M17		0.14–0.20	1.00–1.30	0.80–1.10				19	930	10	15(29)	16(29)
	590A15	*0.13–0.18*	*0.90–1.20*	*0.90–1.20*								
	635M15	*0.12–0.18*	*0.60–0.90*	*0.40–0.80*		*0.70–1.10*		*19*	*770*	*12*	*20*	*22*
	635A14	*0.12–0.17*	*0.70–0.90*	*0.50–0.75*	*0.10 max.*	*0.70–1.00*						
	637M17	*0.14–0.20*	*0.60–0.90*	*0.60–1.00*		*0.85–1.25*		*19*	*930*	*10*	*15*	*16*
	637A16	*0.14–0.19*	*0.70–0.90*	*0.70–1.00*	*0.10 max.*	*0.90–1.20*						
	655M13	*0.10–0.16*	*0.35–0.60*	*0.70–1.00*		*3.00–3.75*		*19*	*1000*	*9*	*30*	*35*
	665M17	*0.14–0.20*	*0.35–0.75*		*0.20–0.30*	*1.50–2.00*		*19*	*770*	*12*	*30*	*35*
	665M20	*0.17–0.23*	*0.35–0.75*		*0.20–0.30*	*1.50–2.00*		*19*	*850*	*11*	*20*	*22*
	665M23	*0.20–0.26*	*0.35–0.75*		*0.20–0.30*	*1.50–2.00*		*19*	*930*	*10*	*12*	*13*

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

Table 8. Case hardening steels: chemical composition and mechanical property requirements *(concluded)*

Steel		Chemical composition						Test bar diameter	R_m min.	A min. on $5.65\sqrt{S_o}$	Impact	
Category 1 (1)	Category 2 (1)	C	Mn	Cr	Mo	Ni	Others				Izod min.	KCV min.
Alloy steels *(concluded)*												
		%	%	%	%	%	%	mm	N/mm^2 (2)		ft·lb	J
708M20		0.17–0.23	0.60–0.90	0.85–1.15	0.15–0.25			19	930	10	15 (29)	16 (29)
	805M17	*0.14–0.20*	*0.60–0.95*	*0.35–0.65*	*0.15–0.25*	*0.35–0.75*	P 0.035 max. S 0.035 max.	*19*	*770*	*12*	*20*	*22*
	805A17	*0.15–0.20*	*0.70–0.90*	*0.40–0.60*	*0.15–0.25*	*0.40–0.70*						
805M20		0.17–0.23	0.60–0.95	0.35–0.65	0.15–0.25	0.35–0.75		19	850	11	15	16
805A20		0.18–0.23	0.70–0.90	0.40–0.60	0.15–0.25	0.40–0.70						
805M22		0.19–0.25	0.60–0.95	0.35–0.65	0.15–0.25	0.35–0.75		19	930	10	10	11
805A22		0.20–0.25	0.70–0.90	0.40–0.60	0.15–0.25	0.40–0.70						
808M17		0.14–0.20	0.70–1.05	0.35–0.65	0.30–0.40	0.35–0.75		19	930	10	20	22
815M17		0.14–0.20	0.60–0.90	0.80–1.20	0.10–0.20	1.20–1.70		19	1080	8	20	22
820M17		0.14–0.20	0.60–0.90	0.80–1.20	0.10–0.20	1.50–2.00		19	1160	8	20	22
822M17		0.14–0.20	0.40–0.70	1.30–1.70	0.15–0.25	1.75–2.25		19	1310	8	20	22
	832M13	*0.10–0.16*	*0.35–0.60*	*0.70–1.00*	*0.10–0.25*	*3.00–3.75*		*19*	*1080*	*8*	*25*	*28*
835M15		0.12–0.18	0.25–0.50	1.00–1.40	0.15–0.30	3.90–4.30		19	1310	8	25	28

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

(2) 1 N/mm^2 = 1 MPa.

(28) Preferred size.

(29) These are new steels which may have been conservatively rated due to limited data.

Table 9. Case hardening steels: heat treatment and maximum hardness requirements

Steel			Requirements for hardenability test		Maximum hardness HB (when specified on the order) in the condition of delivery			
Category 1 (1)	Category 2 (1)	Hardening temperature	Preheat treatment temperature	Austenitizing temperature	Bars and billets for forging	Forgings and bars for machining		
						Normalized	Sub-critically annealed	Normalized and tempered
Carbon, carbon manganese steels								
		°C	°C	°C				
045M10		900–930						
080M15		900–930						
130M15		900–930						
210M15		900–930						
214M15		900–930						
Boron steels								
170H15		–	930–950	925				
173H16		–	930–950	925				
174H20		–	930–950	925				
175H23		–	930–950	925				
Alloy steels								
523H15		–	930–950	925	207	207		
523M15		820–840	–	–	207	207		
527H17		–	930–950	925	–	217		
527M17		820–840	–	–	–	217		
590H17		–	930–950	870	–	217		
590M17		820–840	–	–	–	217		
	635H15	–	*930–950*	*925*	*207*	*207*		
	635M15	*820–840*	–	–	*207*	*207*		
	637H17	–	*930–950*	*925*	*217*	*217*		
	637M17	*820–840*	–	–	*217*	*217*		
	655H13	–	*880–900*	*830*	*255*	–	*255*	*223*
	655M13	*800–820*	–	–	*255*	–	*255*	*223*
	665H17	–	*930–950*	*925*	*207*	*207*		
	665H20	–	*930–950*	*925*	*207*	*207*		
	665H23	–	*930–950*	*925*	*229*	*229*		
	665M17	*820–840*	–	–	*207*	*207*		
	665M20	*820–840*	–	–	*207*	*207*		
	665M23	*820–840*	–	–	*229*	*229*		
708H20		–	930–950	925				
708M20		830–840	–	–	–	–	–	217
	805H17	–	*930–950*	*925*	*207*	*207*		
805H20		–	930–950	925	207	207		
805H22		–	930–950	925	217	217		
	805M17	*820–840*	–	–	*207*	*207*		
805M20		820–840	–	–	207	207		
805M22		820–840	–	–	217	217		
808H17		–	930–950	925	–	–		
808M17		820–840	–	–	–	–		
815H17		–	930–950	925	255	–	255	241
815M17		820–840	–	–	255	–	255	241
820H17		–	880–900	830	277	–	269	248
820M17		820–840	–	–	277	–	269	248
822H17		–	880–900	830	277	–	269	255
822M17		820–840	–	–	277	–	269	255
	832H13	–	*880–900*	*830*	*255*	–	*255*	*248*
	832M13	*800–820*	–	–	*255*	–	*255*	*248*
835H15		–	880–900	830	277	–	277	269
835M15		800–820 (30)	–	–	277	–	277	269

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

(30) Shall also be stress relieved at a temperature not exceeding 200 °C.

Section five. Specific requirements for stainless and heat resisting steels

Tables 10 and 11 specify requirements for ferritic, martensitic and austenitic stainless and heat resisting steels.

Especially in the case of austenitic steels, changes have been made to take into account agreements that have been reached in international harmonization discussions and mainly concern the chemical composition ranges. The changes include the introduction of 2.0 % to 2.5 % and 2.5 % to 3.0 % molybdenum ranges in place of the single range 2.25 % to 3.0 % molybdenum, the removal of the previous minimum silicon and manganese limits and for certain unstabilized steels, the chromium range has been widened allowing chromium down to 17.0 %.

Table 10. Ferritic and martensitic stainless and heat resisting steels: chemical composition, heat treatment and mechanical property requirements

Steel (7)	Chemical composition (maximum unless range stated)									Softened condition HB max.	Heat treatment condition	LRS	Heat treatment	R_m	R_e min.	A min. on $5.65\sqrt{S_o}$	Impact		$R_{p0.2}$ (10) min.	HB
	C	Si	Mn	P	S	Cr	Mo	Ni	Se								Izod min.	KCV min.		
Ferritic steels																				
	%	%	%	%	%	%	%	%	%			mm	°C	N/mm² (2)	N/mm² (2)		ft·lb	J	N/mm² (2)	
403S17	0.08	1.0	1.0	0.040	0.030	12.0–14.0	–	0.50	–	170	–	150	700–780 (31)	420 min.	280	20	–	–	245	170 max.
430S17	0.08	1.0	1.0	0.040	0.030	16.0–18.0	–	0.50	–	170	–	63	750–820 (32)	430 min.	280	20	–	–	245	170 max.
Martensitic steels																				
410S21	0.09–0.15	1.0	1.0	0.040	0.030	11.5–13.5	–	1.00	–	207			950–1020 (33)							
											P	150	650–750 (34)	550–700	370	20	≤ 63 mm 40 > 63 mm 25	–	340	152–207
											R	63	600–700 (34)	700–850	525	15	25	–	495	201–255
416S21	0.09–0.15	1.0	1.5	0.060	0.15–0.35	11.5–13.5	0.60	1.00	–	207			950–1020 (33)							
											P	150	650–750 (34)	550–700	370	15	25	–	340	152–207
											R	63	600–700 (34)	700–850	525	11	20	–	495	201–255
416S29	0.14–0.20	1.0	1.5	0.060	0.15–0.35	11.5–13.5	0.60	1.00	–	217			950–1020 (33)							
											R	150	650–750 (34)	700–850	525	11	20	–	495	201–255
											S	29	600–700 (34)	775–925	585	10	10	–	555	223–277
416S37	0.20–0.28	1.0	1.5	0.060	0.15–0.35	12.0–14.0	0.60	1.00	–	229			950–1020 (33)							
											R	150	650–750 (34)	700–850	525	11	20	–	495	201–255
											S	150	600–700 (34)	775–925	585	10	10	–	555	223–277
416S41	0.09–0.15	1.0	1.5	0.060	0.060	11.5–13.5	0.60	1.00	0.15–0.35	179			950–1020 (33)							
											P	150	650–750 (34)	550–700	370	15	25	–	340	152–207
											R	63	600–700 (34)	700–850	525	11	20	–	495	201–255
420S29	0.14–0.20	1.0	1.0	0.040	0.030	11.5–13.5	–	1.00	–	217			950–1020 (33)							
											R	150	650–750 (34)	700–850	525	15	≤ 63 mm 25 > 63 mm 20	–	495	201–255
											S	29	600–700 (34)	775–925	585	13	20	–	555	223–277
420S37	0.20–0.28	1.0	1.0	0.040	0.030	12.0–14.0	–	1.00	–	229			950–1020 (33)							
											R	150	650–750 (34)	700–850	525	15	≤ 63 mm 25 > 63 mm 20	–	495	201–255
											S	150	600–700 (34)	775–925	585	13	≤ 63 mm 20 > 63 mm 10	–	555	223–277
431S29	0.12–0.20	1.0	1.0	0.040	0.030	15.0–18.0	–	2.0–3.0	–	277			950–1020 (33)							
											T	150	550–650 (34) (35)	850–1000	680	11	≤ 63 mm 25 > 63 mm 15	–	635	248–302

(2) 1 N/mm² = 1 MPa.

(7) All the steels are category 1.

(10) When specifically ordered.

(31) Air cooled or furnace cooled.

(32) Cooled freely in air.

(33) Oil or air hardened.

(34) Tempered.

(35) When 0.2 % proof stress is specified, it is recommended that a double tempering treatment be used:
(a) 640 °C to 680 °C followed by
(b) 590 °C to 610 °C.

Table 11. Austenitic stainless and heat resisting steels: chemical composition, softening treatment and mechanical property requirements

Steel(7)	Chemical composition (maximum unless range stated)									Softening temperature	Maximum section	R_m min.	A min. on $5.65\sqrt{S_o}$	$R_{p\,0.2}$ (10)	$R_{p\,1.0}$ (10)	Sensitization period (see 1.15.6)	HB max. (36)
	C	Si	Mn	P	S	Cr	Mo	Ni	Others								
Austenitic steels																	
	%	%	%	%	%	%	%	%	%	°C	mm	N/mm²(2)		N/mm²(2)	N/mm²(2)	min	
302S31	0.12	1.0	2.0	0.045	0.030	17.0–19.0	–	8.0–10.0	–	1000–1100	160	510	40	190	225	–	183
304S11	0.030	1.0	2.0	0.045	0.030	17.0–19.0	–	9.0–12.0	–	1000–1100	160	480	40	180	215	30	183
304S15	0.06	1.0	2.0	0.045	0.030	17.5–19.0	–	8.0–11.0	–	1000–1100	160	480	40	195	230	15	183
304S31	0.07	1.0	2.0	0.045	0.030	17.0–19.0	–	8.0–11.0	–	1000–1100	160	490	40	195	230	15	183
321S31	0.08	1.0	2.0	0.045	0.030	17.0–19.0	–	9.0–12.0	Ti 5C–0.80	1000–1100	160	510	35	200	235	30	183
347S31	0.08	1.0	2.0	0.045	0.030	17.0–19.0	–	9.0–12.0	Nb 10C–1.00	1000–1100	160	510	30	205	240	30	183
316S11	0.030	1.0	2.0	0.045	0.030	16.5–18.5	2.00–2.50	11.0–14.0	–	1000–1100	160	490	40	190	225	30	183
316S13	0.030	1.0	2.0	0.045	0.030	16.5–18.5	2.50–3.00	11.5–14.5	–	1000–1100	160	490	40	190	225	30	183
316S31	0.07	1.0	2.0	0.045	0.030	16.5–18.5	2.00–2.50	10.5–13.5	–	1000–1100	160	510	40	205	240	15	183
316S33	0.07	1.0	2.0	0.045	0.030	16.5–18.5	2.50–3.00	11.0–14.0	–	1000–1100	160	510	40	205	240	15	183
320S31	0.08	1.0	2.0	0.045	0.030	16.5–18.5	2.00–2.50	11.0–14.0	Ti 5C–0.80	1000–1100	160	510	35	210	245	30	183
310S31	0.15	1.5	2.0	0.045	0.030	24.0–26.0	–	19.0–22.0	–	1000–1100	160	510	40	205	240	–	207
303S31	0.12	1.0	2.0	0.060	0.15–0.35	17.0–19.0	1.00(37)	8.0–10.0	–	1000–1100	160	510	40	190	225	–	183
303S42	0.12	1.0	2.0	0.060	0.060	17.0–19.0	1.00(37)	8.0–10.0	Se 0.15–0.35	1000–1100	160	510	40	190	225	–	183
325S31	0.12	1.0	2.0	0.045	0.15–0.35	17.0–19.0	–	8.0–11.0	Ti 5C–0.90	1000–1100	160	510	35	200	235	30	183

(2) 1 N/mm² = 1MPa.
(7) All the steels are category 1.
(10) When specifically ordered.
(36) Straightening by reeling or cold rectification of austenitic steels can increase the surface hardness above the specified maximum.
(37) Optional addition.

Section six. Specific requirements for sizes and tolerances

6.1 Sizes

6.1.1 Billets for forging. Billets for forging shall be supplied in accordance with the nominal sizes given in table 12.

6.1.2 Black bar. The sizes of bars shall be selected from BS 6722.

NOTE. Sizes other than those in BS 6722 may be available.

6.2 Mass/unit length tolerances

Billets for forging shall be supplied in accordance with table 12.

6.3 Dimensional tolerances

6.3.1 Black bar. Tolerances shall be in accordance with tables 13 to 15.

6.3.2 Drop and press forgings and upset forgings made on horizontal forging machines. Drop and press forgings and upset forgings made on horizontal forging machines shall comply with BS 4114 unless otherwise agreed between the purchaser and the supplier.

6.4 Straightness

6.4.1 Billets and bars for machining. Billets and bars for machining shall be straightened to within 2 mm in any 1 m length.

6.4.2 Billets and bars for forging. Billets and bars for forging shall be straight to within 1/250 in any unit length.

6.5 Length

The standard tolerance on length for random length bars shall be 600 mm.

NOTE. Closer tolerances may be agreed between the purchaser and the supplier.

Table 12. Billets (other than stainless steel) for forging: standard mass per metre and tolerances

Round cornered square billets (38)			Round billets		
Nominal size (39) across flats	Standard mass	Permissible variations on mass	Nominal size (40) diameter	Standard mass	Permissible variations on mass
mm	kg/m	%	mm	kg/m	%
50	19.3		76	35.6	
51	20.1		80	39.5	
55	23.3		85	44.5	
57	25.0		90	49.9	
60	27.7		95	55.6	
63	30.6		100	61.7	
65	32.7		105	68.0	
67	34.6		110	74.6	
70	37.7		115	81.5	
73	41.0		120	88.8	
75	43.2		125	96.3	
76	44.4	± 2.5 or,	130	104.2	± 2.5 or,
80	49.1	when a minimum	135	112.4	when a minimum
83	52.9	mass is specified,	140	120.8	mass is specified,
85	55.5	+5, −0;	145	129.6	+5, −0;
86	56.8	when a maximum	150	138.7	when a maximum
90	62.2	mass is specified,	155	148.1	mass is specified,
92	65.2	+0, −5.	160	157.8	+0, −5.
95	69.5		165	167.8	
98	74.0		170	178.2	
100	77.0		175	188.8	
105	84.9		180	199.8	
108	89.8		185	211.0	
110	93.1		190	222.6	
115	101.7		195	234.4	
120	110.2		200	246.6	
127	124.0		205	259.1	
130	129.7		210	271.9	
135	140.3		215	285.0	
140	151.3		220	298.4	

(38) When round cornered square billets are supplied to the mass/unit length requirements of this table, it should be realized that, because of the differences in roll pass design, i.e. corner radius and angle between sides, which may exist from mill to mill, there may be slight differences in the actual size of billet of the same standard mass.

(39) These are preferred sizes for round cornered square billets.

(40) For other sizes of round billets, standard masses shall be calculated using the formula:

$$\text{Standard mass (in kg/m)} = \frac{\pi \times (\text{nominal size, in mm})^2 \times 0.00785}{4}$$

Table 13. Tolerances for hot rolled round and square bar and rough turned rounds

Size	Permitted variation					
	General applications				Special applications	
	Primary-rolled round material		Re-rolled material		Re-rolled material	
	Diameter	Out of section (41)	Diameter or width across flats	Out of section (41)	Diameter or width across flats	Out of section (41)
mm	± mm	mm	± mm	mm	± mm	mm
⩽ 16	–	–	0.2	0.3	0.2	0.3
> 16 ⩽ 26	–	–	0.3	0.5	0.2	0.3
> 26 ⩽ 38	–	–	0.4	0.6	0.25	0.4
> 38 ⩽ 51	–	–	0.5	0.8	0.3	0.5
> 51 ⩽ 64	–	–	0.6	0.9	0.4	0.6
> 64 ⩽ 76	–	–	0.7	1.1	0.5	0.8
> 76 ⩽ 90	1.3	2.0	0.7	1.1		
> 90 ⩽ 120	1.5	2.3	0.8	1.2		
> 120 ⩽ 160	2.0	3.0				
> 160 ⩽ 200	2.5	3.8				
> 200	3.0	4.5				

(41) In relation to table 13, the definition of 'out of section' is as follows:

Round bar. The difference between the maximum and the minimum diameter of the bar measured at the same cross section.

Square bar. The difference between the two dimensions measured across the two pairs of opposing (parallel) sides at a common cross section of the bar.

NOTE. By agreement between purchaser and supplier, the tolerances may be all plus or all minus, e.g. the general applications tolerance for 16 mm round may be either plus 0.4 mm or minus 0.4 mm.

Table 14. Tolerances for hot rolled hexagonal bar

Size	Permitted variation			
	General applications		Special applications	
	Re-rolled material		Re-rolled material	
	Width across flats	Out of section (41)	Width across flats	Out of section (41)
mm	± mm	mm	± mm	mm
⩽ 16	0.2	0.3	0.2	0.3
> 16 ⩽ 26	0.3	0.5	0.2	0.3
> 26 ⩽ 38	0.4	0.6	0.25	0.4
> 38 ⩽ 51	0.5	0.8	0.3	0.5
> 51 ⩽ 64	0.6	0.9	0.4	0.6
> 64 ⩽ 76	0.7	1.1	0.5	0.8

(41) In relation to table 14, the definition of 'out of section' is as follows:

Hexagonal bar. The difference between the least and the greatest dimensions measured across the three pairs of opposing (parallel) flats at a common cross section of the bar.

NOTE. By agreement between purchaser and supplier, the tolerances may be all plus or all minus, e.g. the general applications tolerance for 16 mm section may be either plus 0.4 mm or minus 0.4 mm.

Table 15. Tolerances for hot rolled flat bar

Size	Permitted variation	
	General applications	Special applications
mm	± mm	± mm
Width		
⩾ 10 ⩽ 35	0.5	0.4
> 35 ⩽ 75	0.8	0.6
> 75 ⩽ 100	1.0	0.7
> 100 ⩽ 125	1.3	0.9
> 125 ⩽ 150	1.5	1.0
Thickness		
⩽ 10	0.4	0.3
> 10 ⩽ 20	0.5	0.3
> 20 ⩽ 40	0.6	0.4
> 40 ⩽ 60	0.8	0.5
> 60	1.0	0.7

NOTE. By agreement between purchaser and supplier, the tolerances may be all plus or all minus, e.g. the standard tolerance on width for 35 mm wide flats may be either plus 1.0 mm or minus 1.0 mm.

Appendices

Appendix A. Hardenability curves for through hardening boron steels and case hardening steels

This appendix presents the hardenability data for the H grades specified in sections three and four in graphical form. This enables a pictorial assessment of the hardenability characteristics of a particular steel to be made and also facilitates the comparison of one H grade with another.

It is important that these graphs are not used for specification purposes. The values to be used are those specified in table 6 (through hardening boron steels) and table 7 (case hardening steels). They should be selected as recommended in BS 4437.

The graphs contained in this appendix are as follows:

A.1 Hardenability curves for through hardening boron steels

A.1.1 170H20
A.1.2 170H36
A.1.3 170H41
A.1.4 185H40

A.2 Hardenability curves for case hardening steels

A.2.1 Boron steels

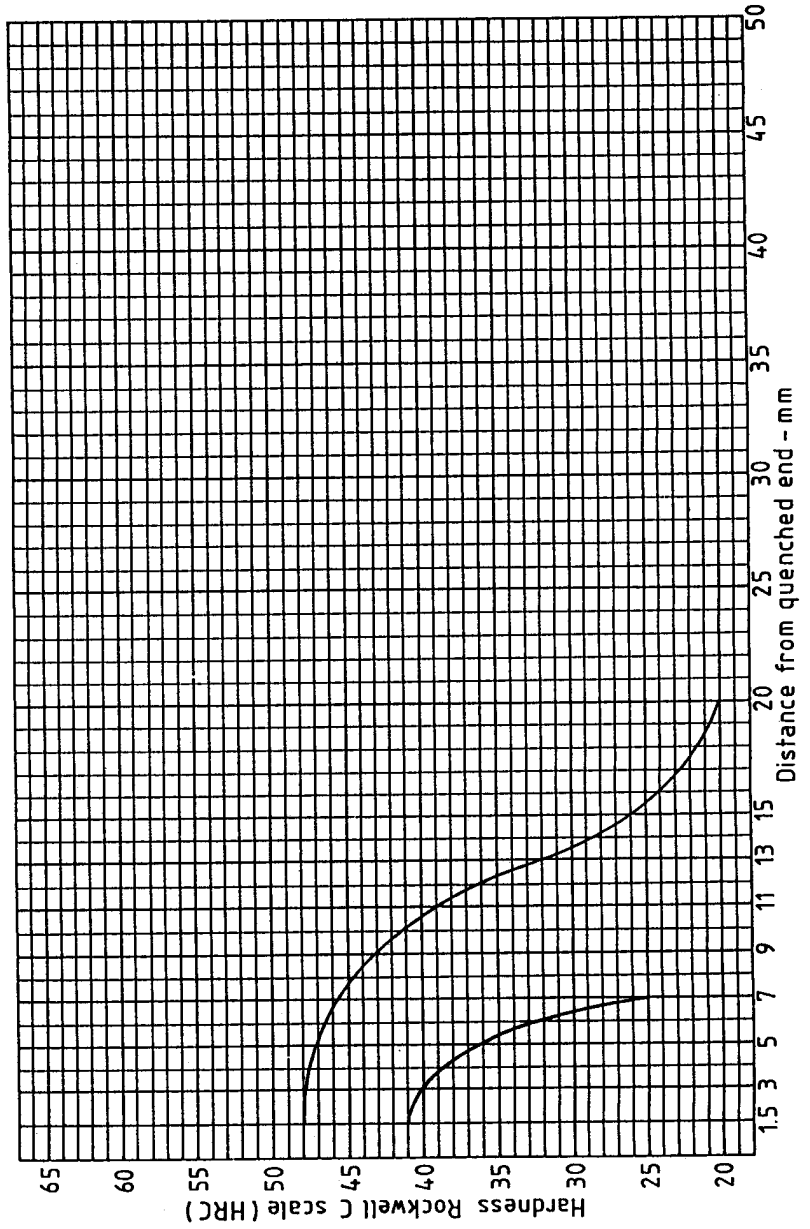
A.2.1.1 170H15
A.2.1.2 173H16
A.2.1.3 174H20
A.2.1.4 175H23

A.2.2 Alloy steels

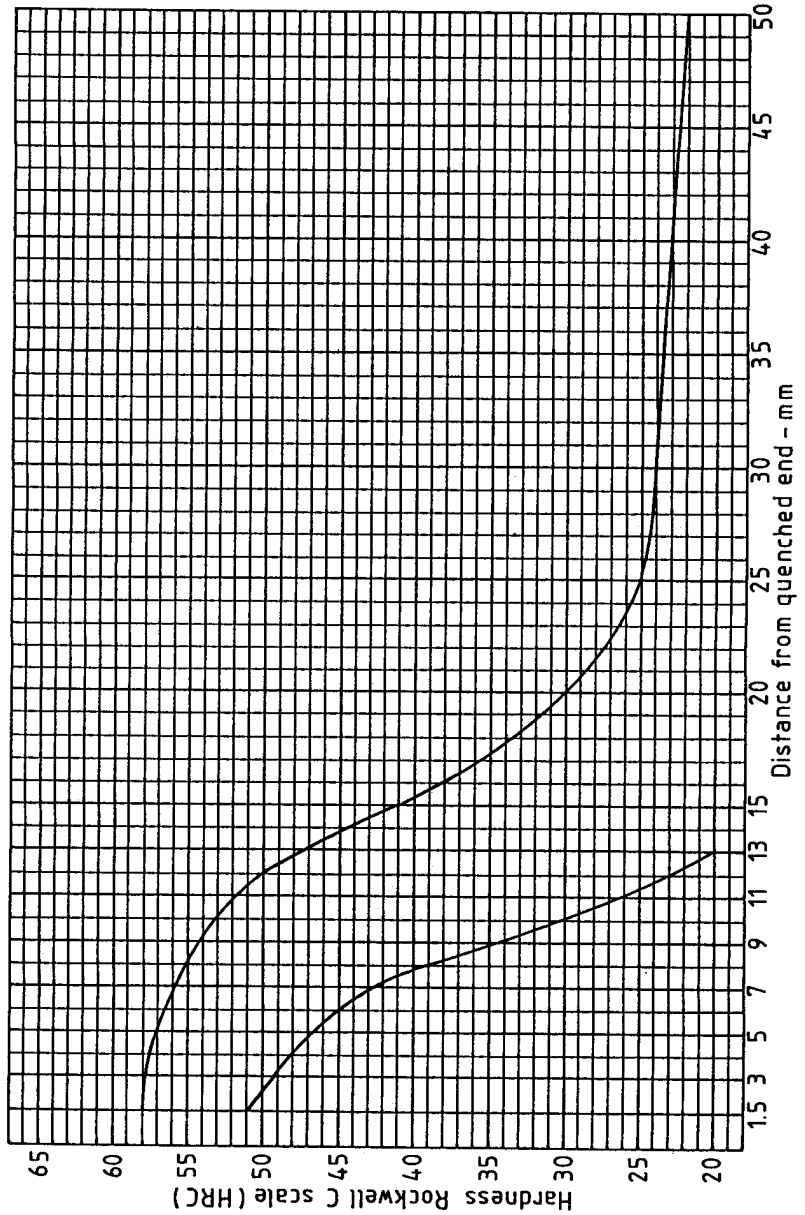
A.2.2.1 523H15
A.2.2.2 527H17
A.2.2.3 590H17
A.2.2.4 635H15
A.2.2.5 637H17
A.2.2.6 655H13
A.2.2.7 665H17
A.2.2.8 665H20
A.2.2.9 665H23
A.2.2.10 708H20
A.2.2.11 805H17
A.2.2.12 805H20
A.2.2.13 805H22
A.2.2.14 808H17
A.2.2.15 815H17
A.2.2.16 820H17
A.2.2.17 822H17
A.2.2.18 832H13
A.2.2.19 835H15

A.1 Hardenability curves for through hardening boron steels (for guidance only)

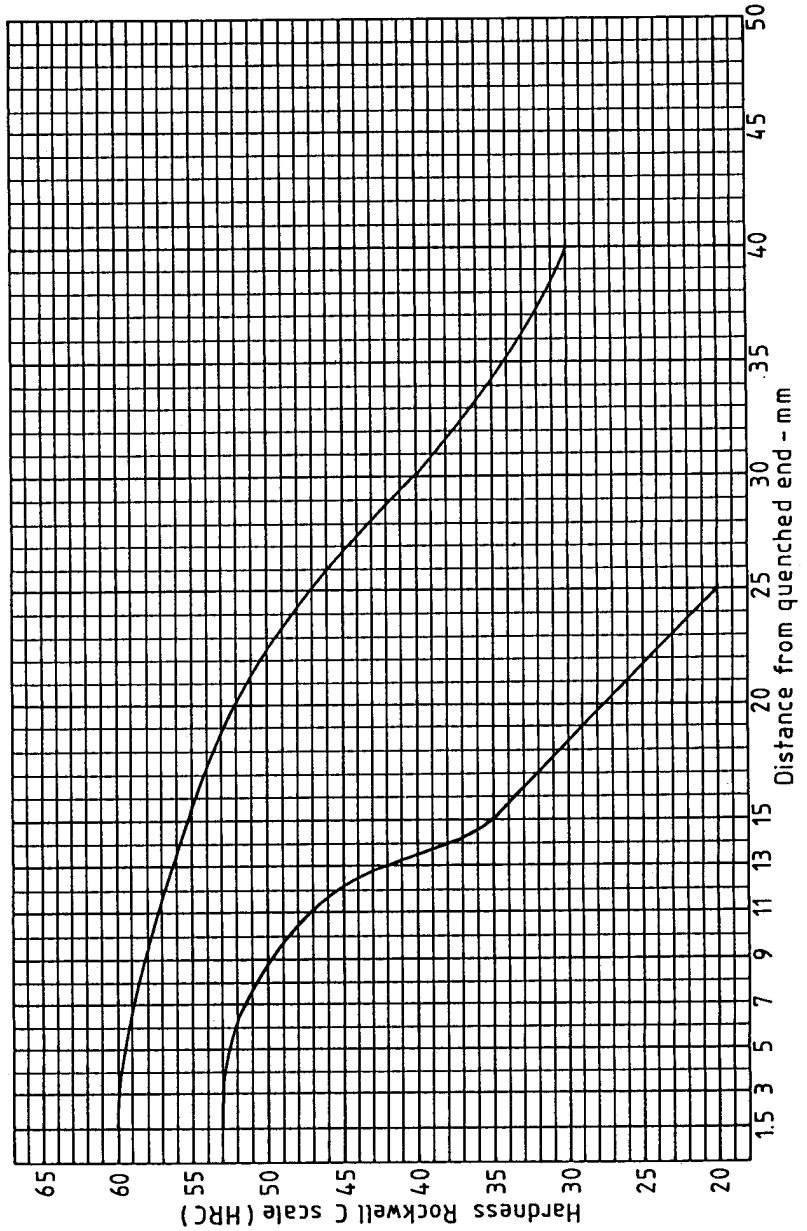
A.1.1 Steel 170H20

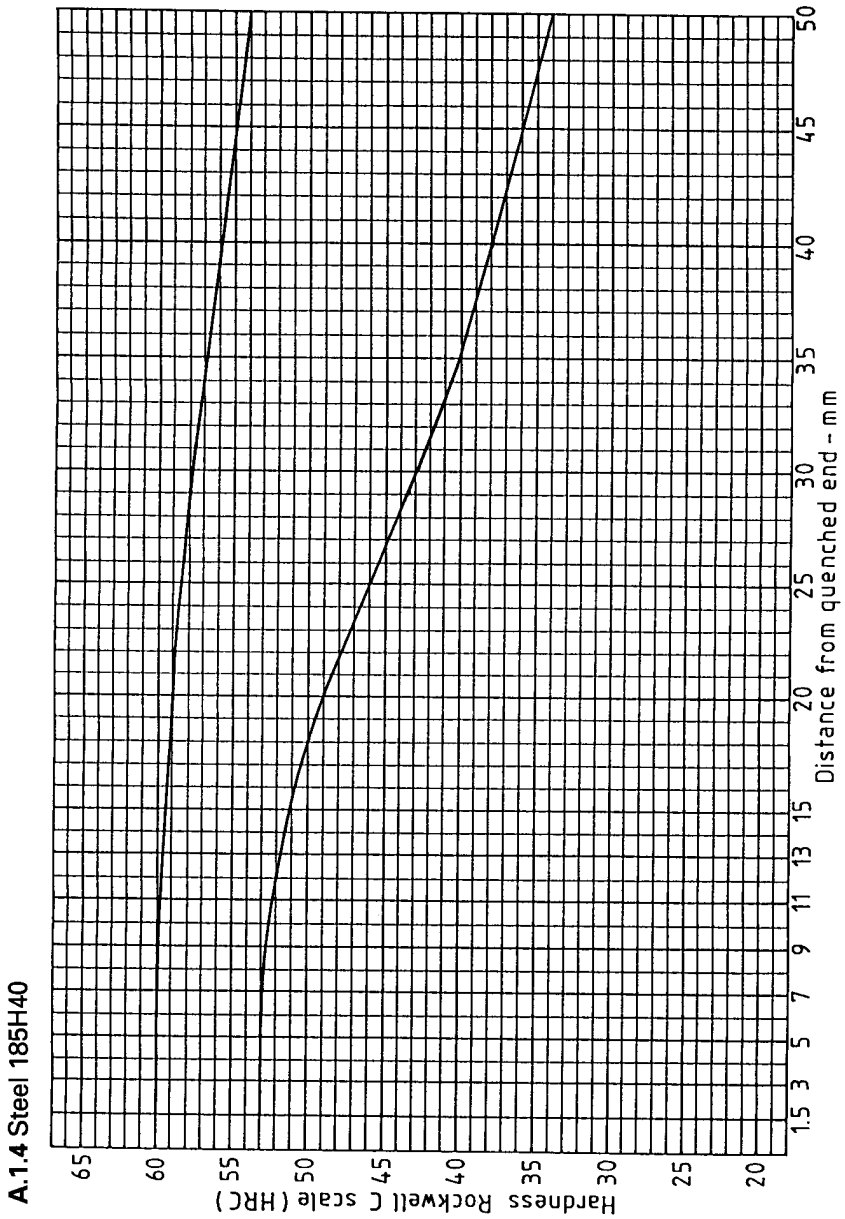


A.1.2 Steel 170H36



A.1.3 Steel 170H41



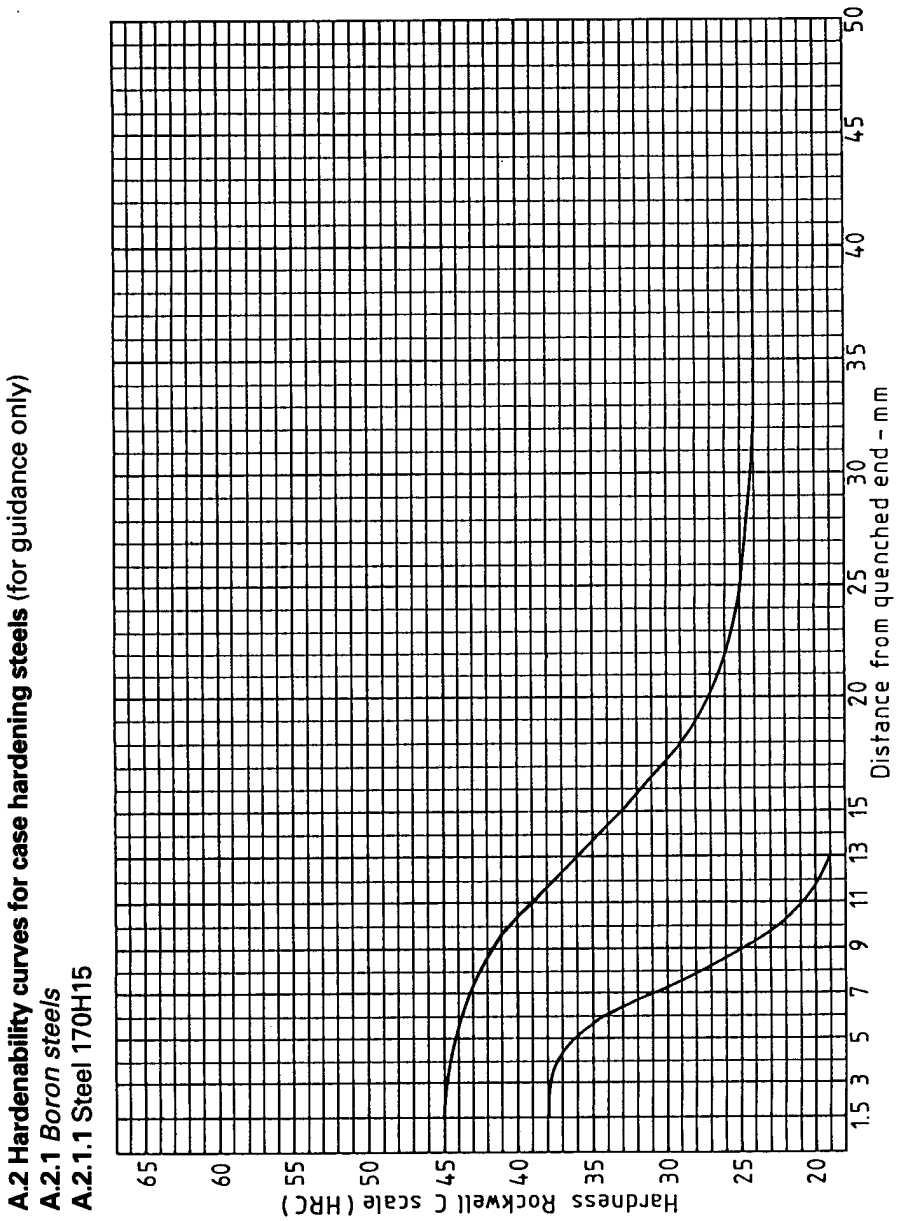


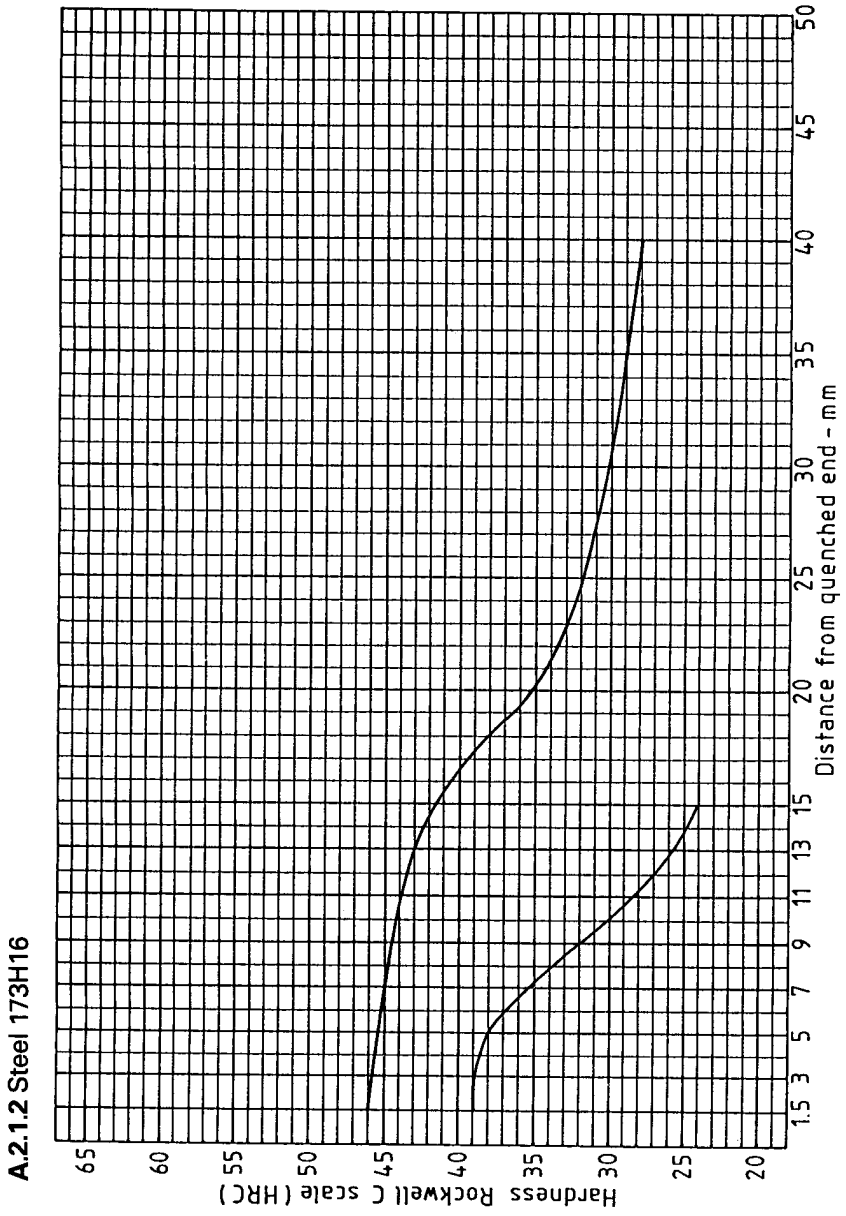
A.1.4 Steel 185H40

A.2 Hardenability curves for case hardening steels (for guidance only)

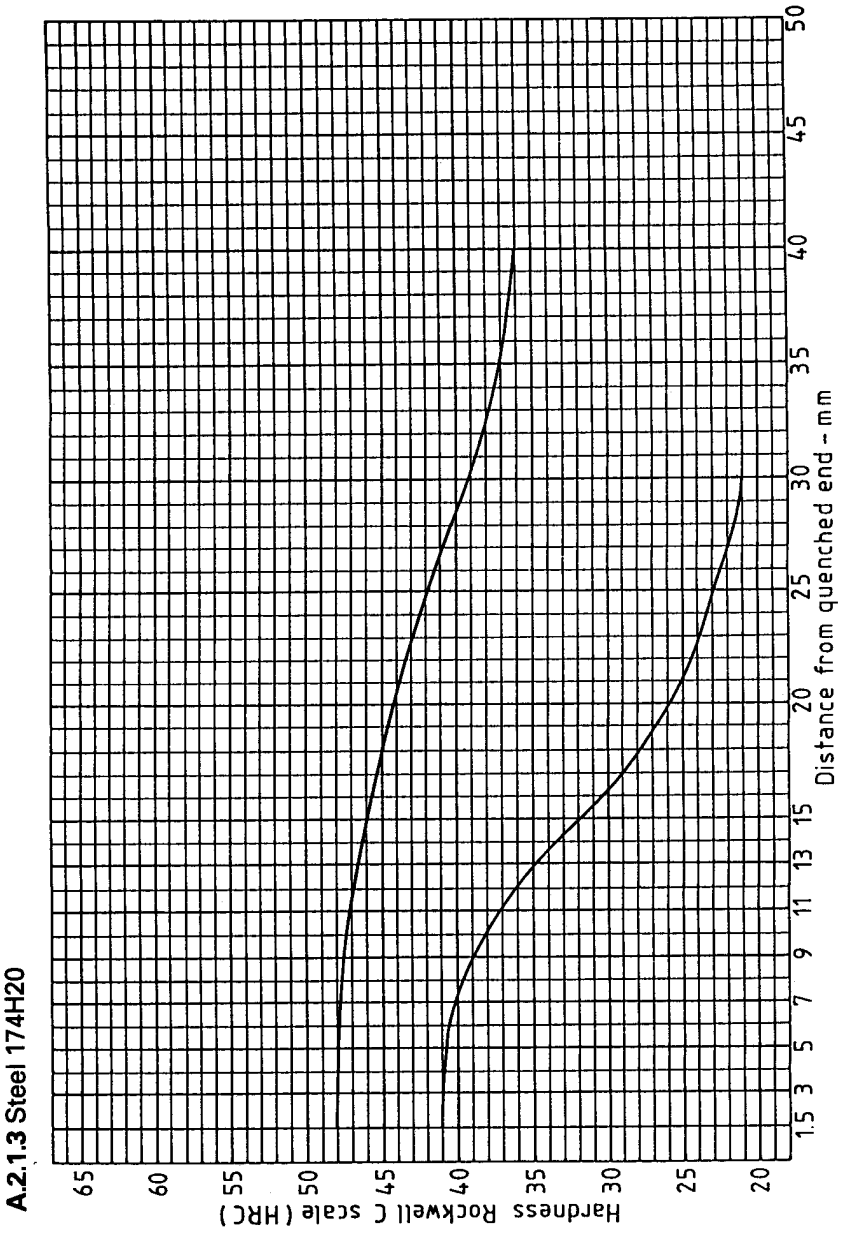
A.2.1 *Boron steels*

A.2.1.1 Steel 170H15

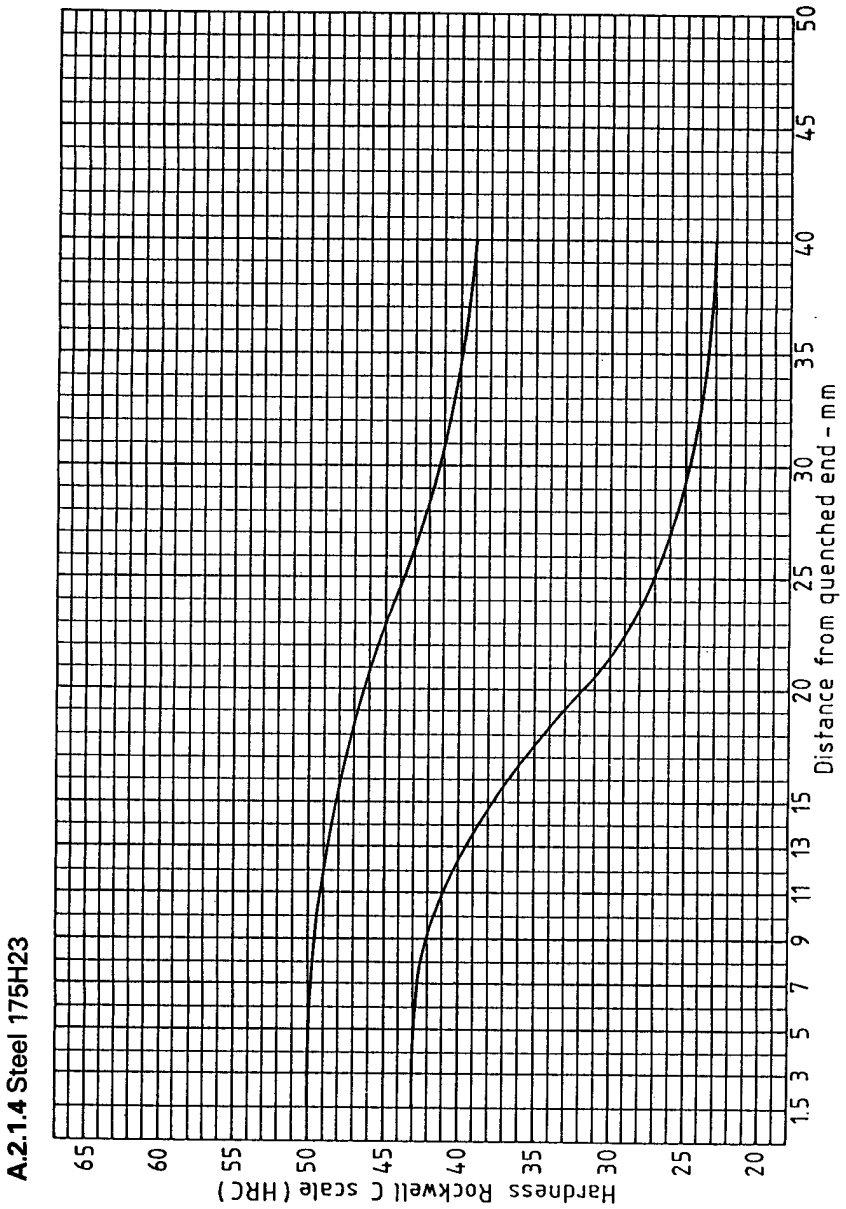




A.2.1.2 Steel 173H16

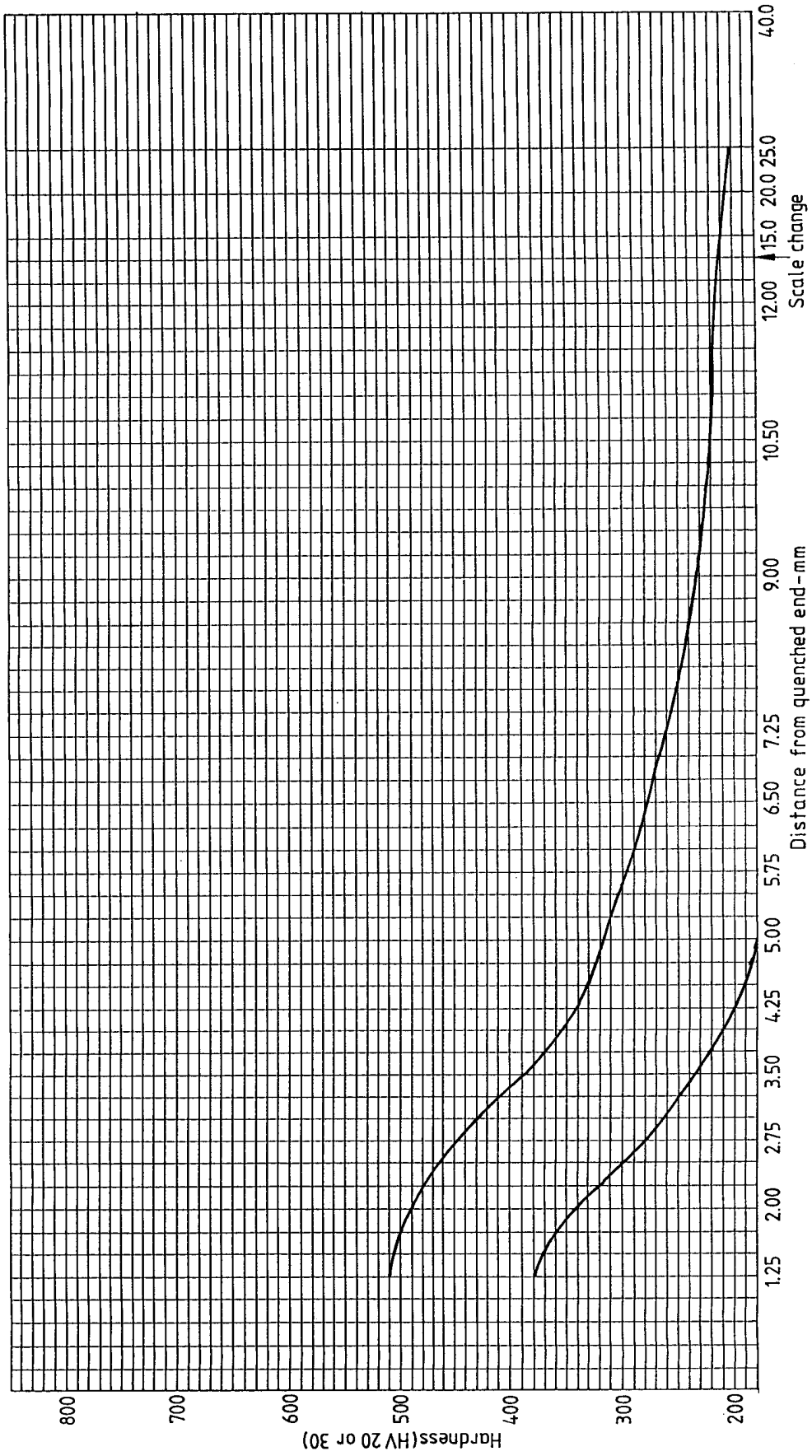


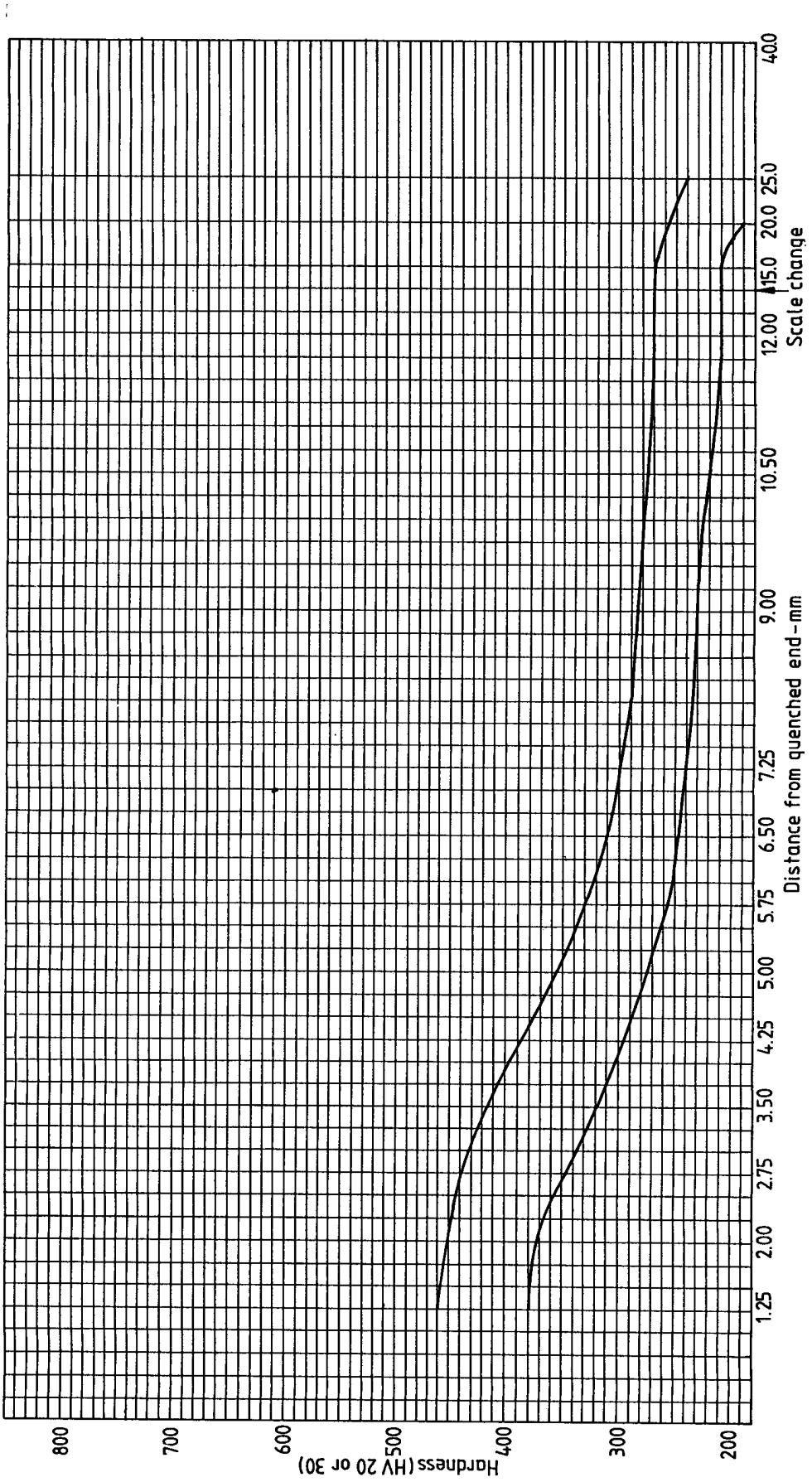
A.2.1.3 Steel 174H20



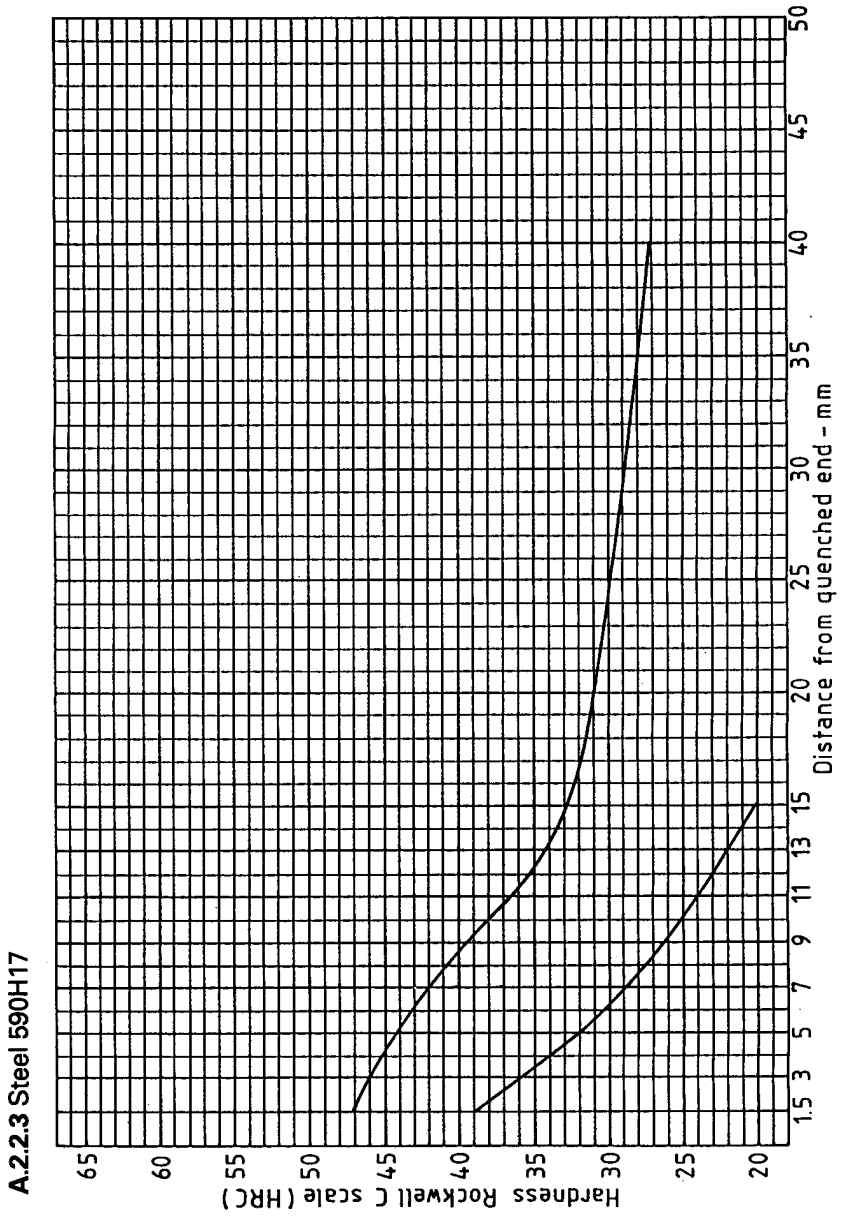
A.2.1.4 Steel 175H23

A.2.2 *Alloy steels*
A.2.2.1 Steel 523H15

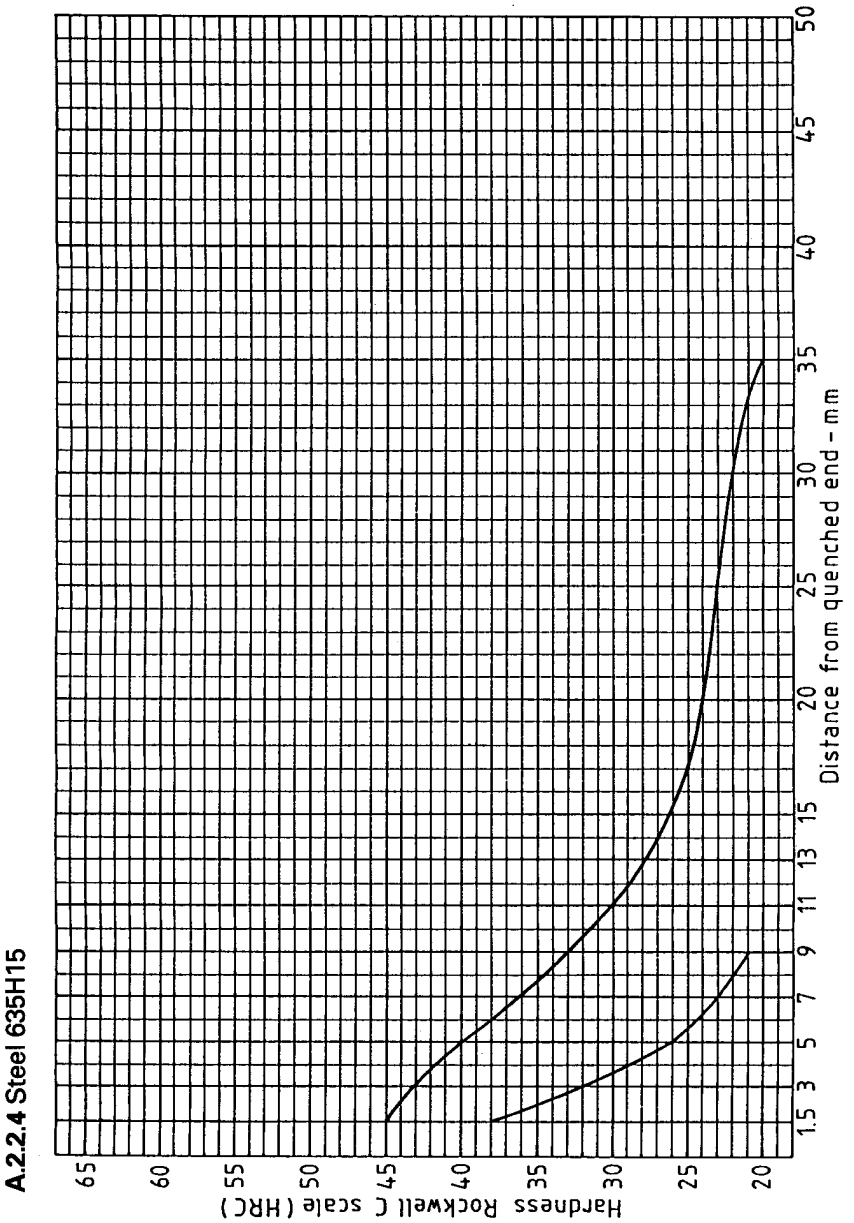




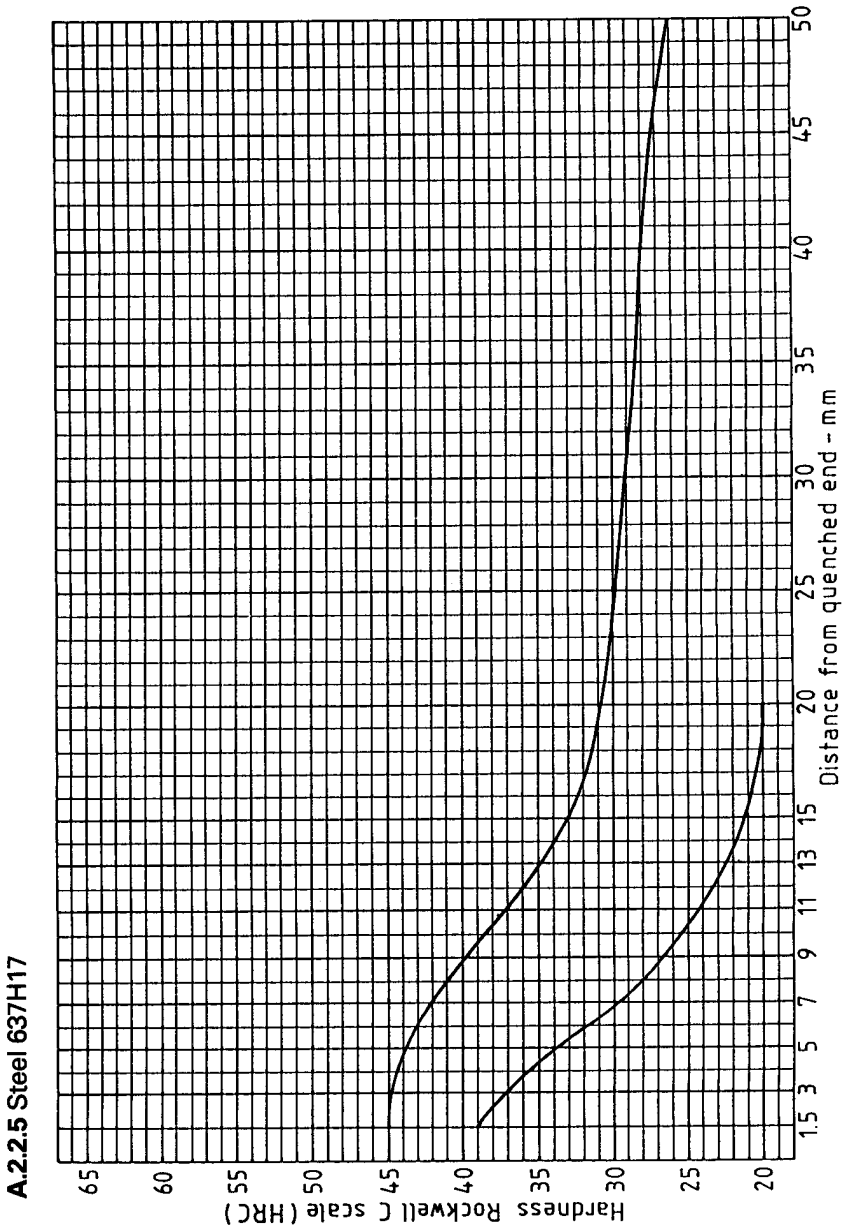
A.2.2.2 Steel 527H17



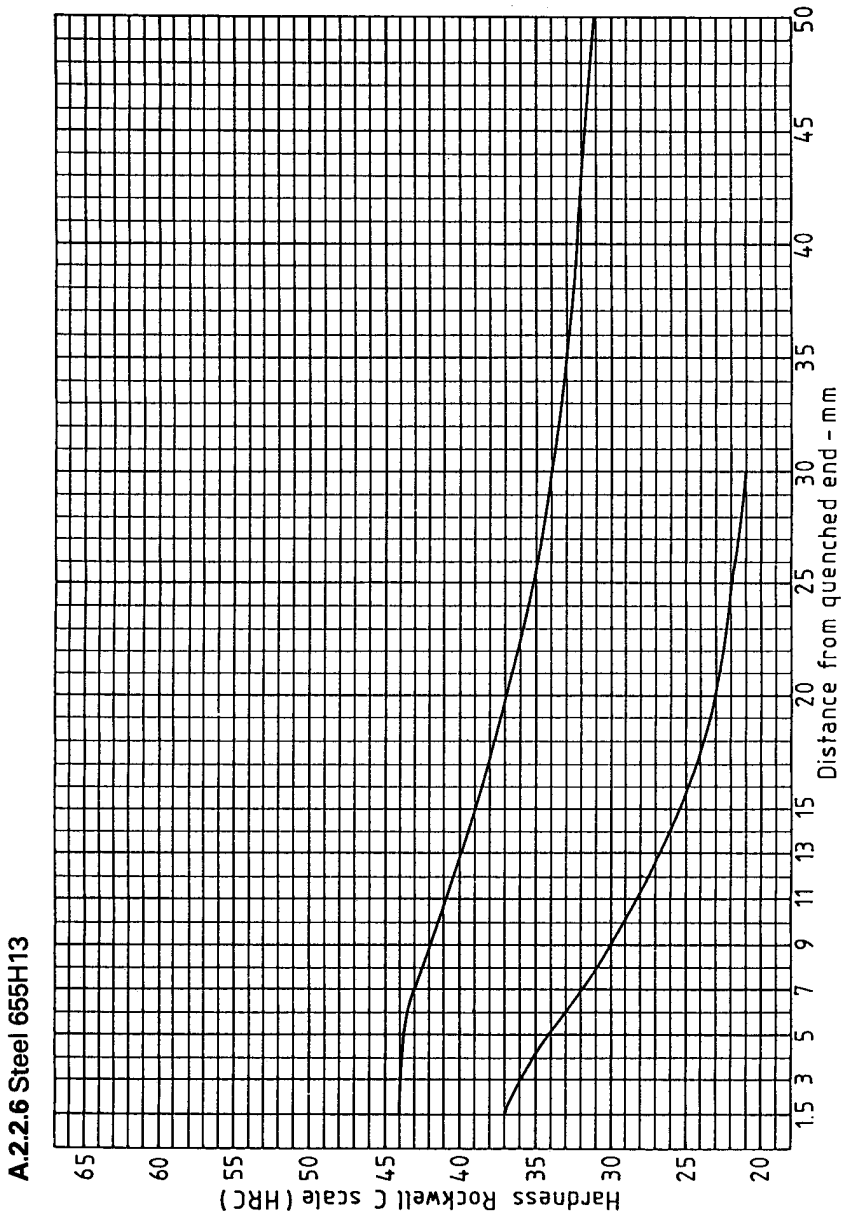
A.2.2.3 Steel 590H17



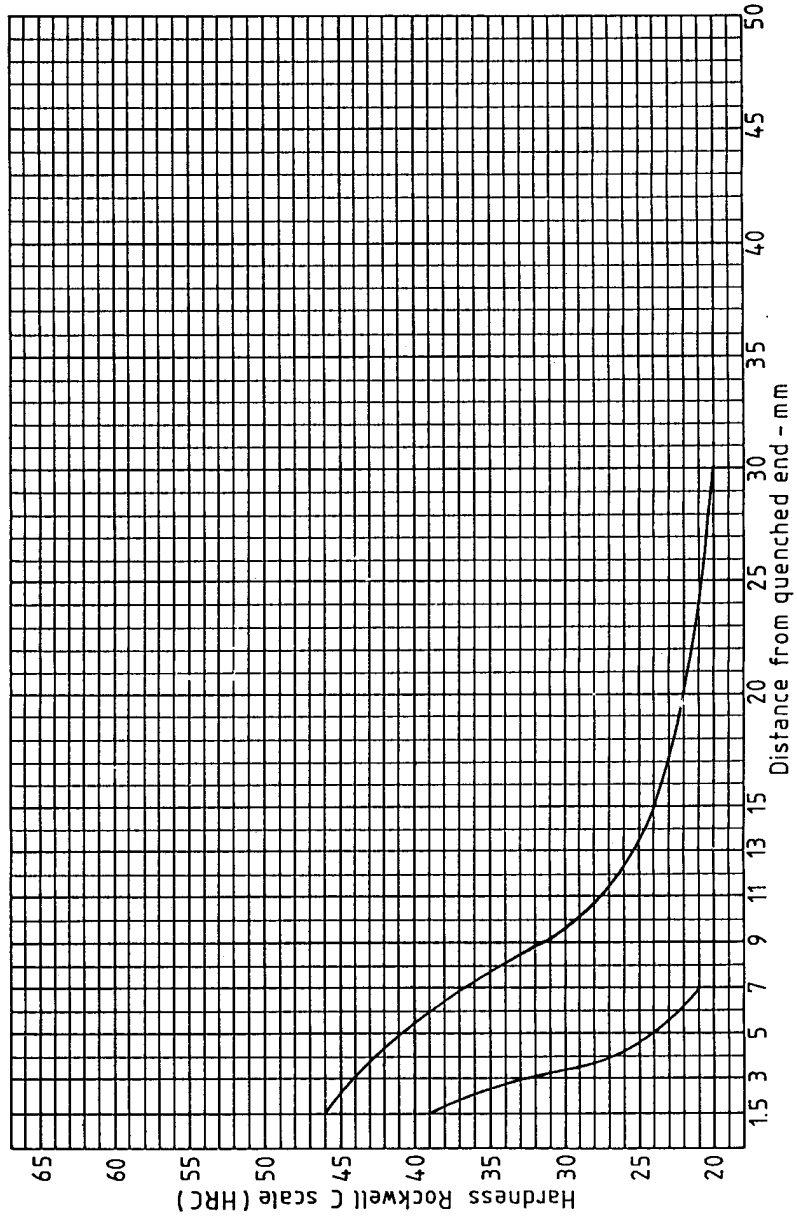
A.2.2.4 Steel 635H15



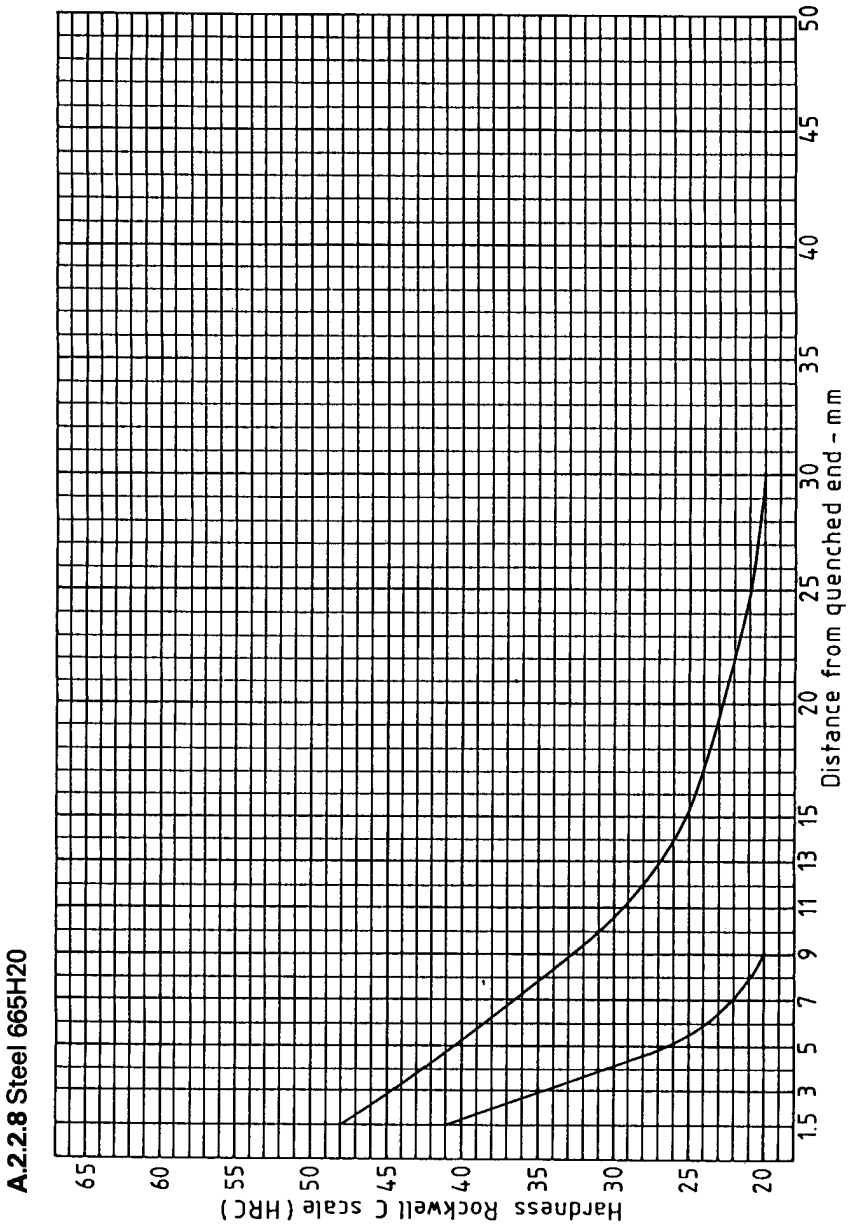
A.2.2.5 Steel 637H17



A.2.2.6 Steel 655H13

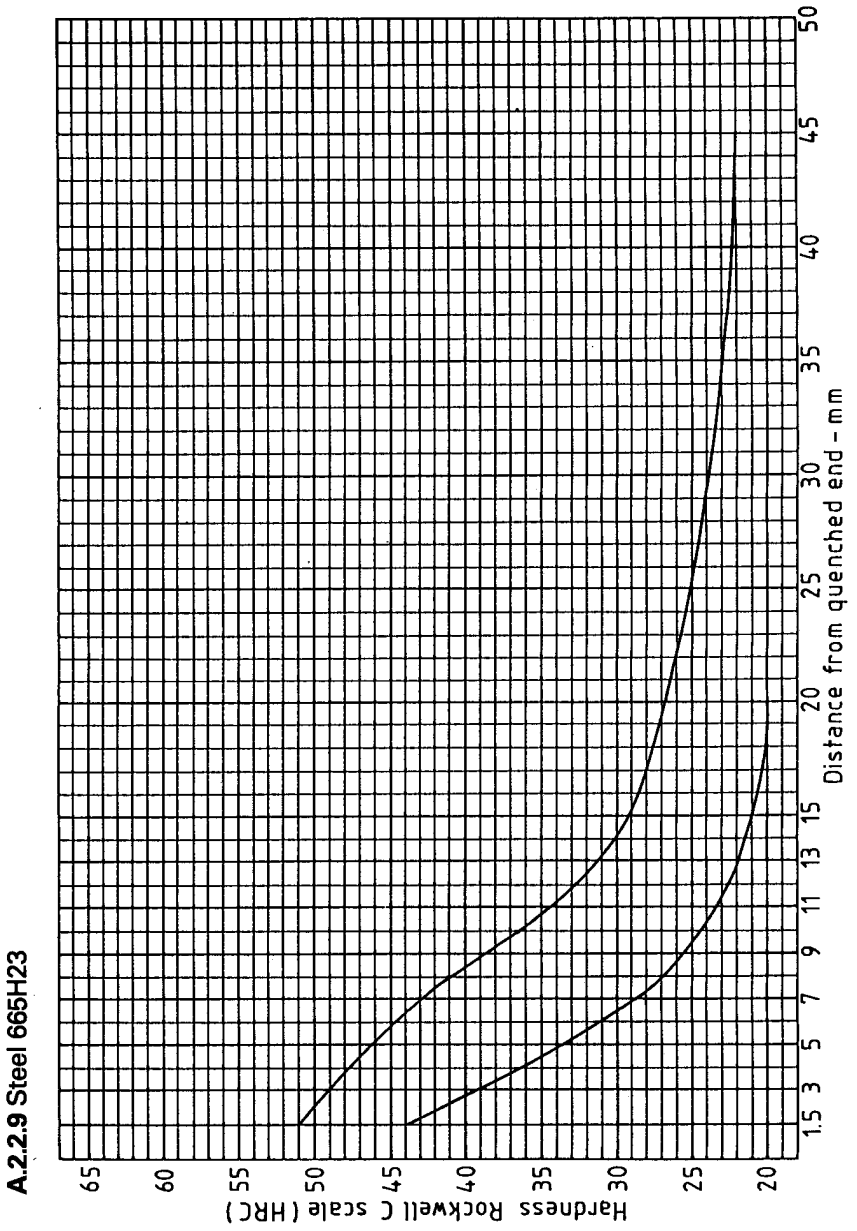


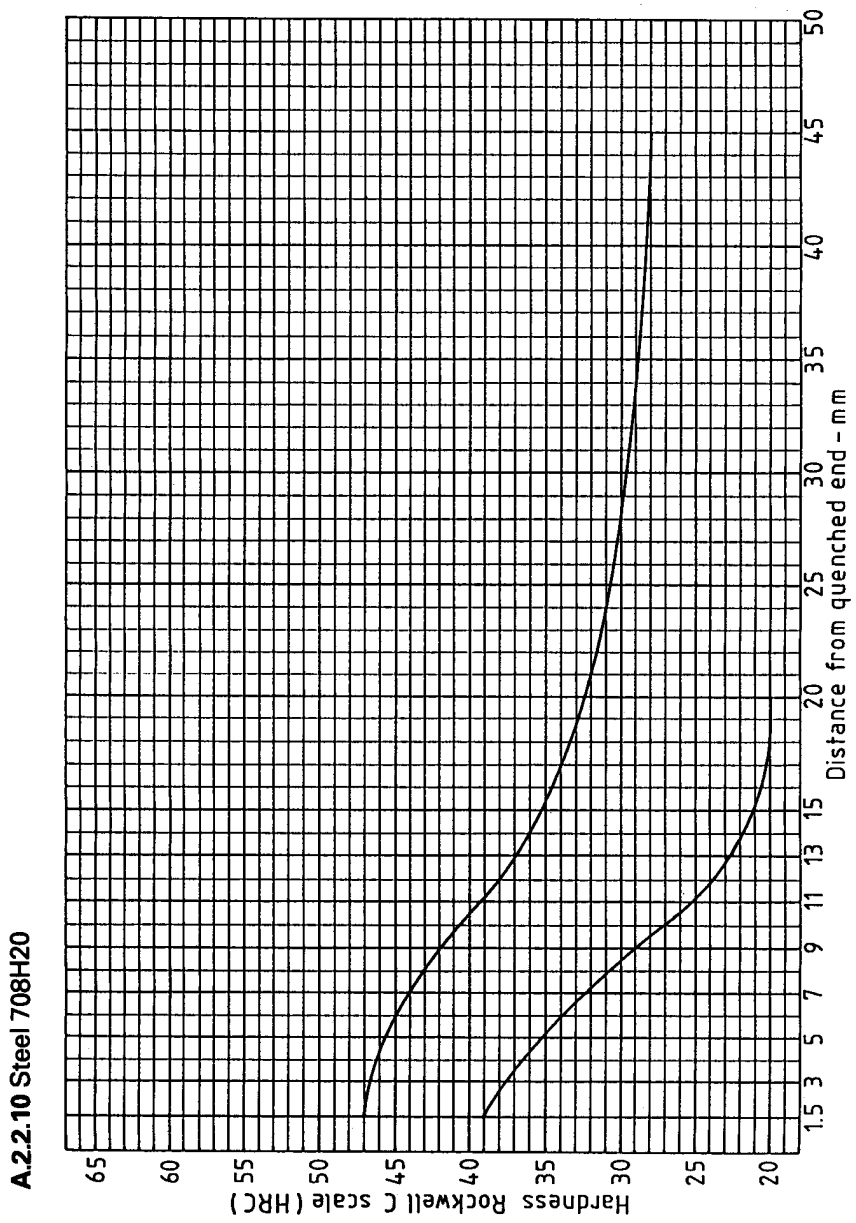
A.2.2.7 Steel 665H17



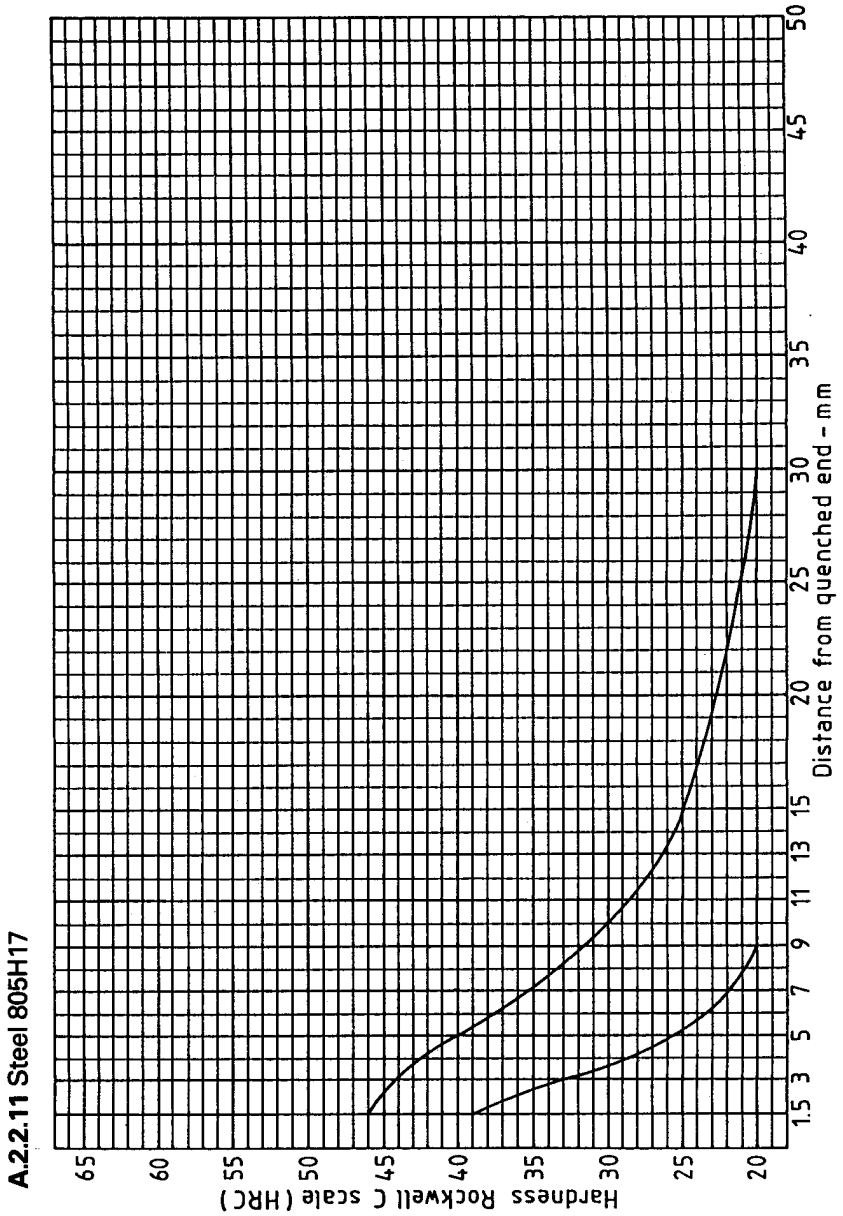
A.2.2.8 Steel 665H20

A.2.2.9 Steel 665H23

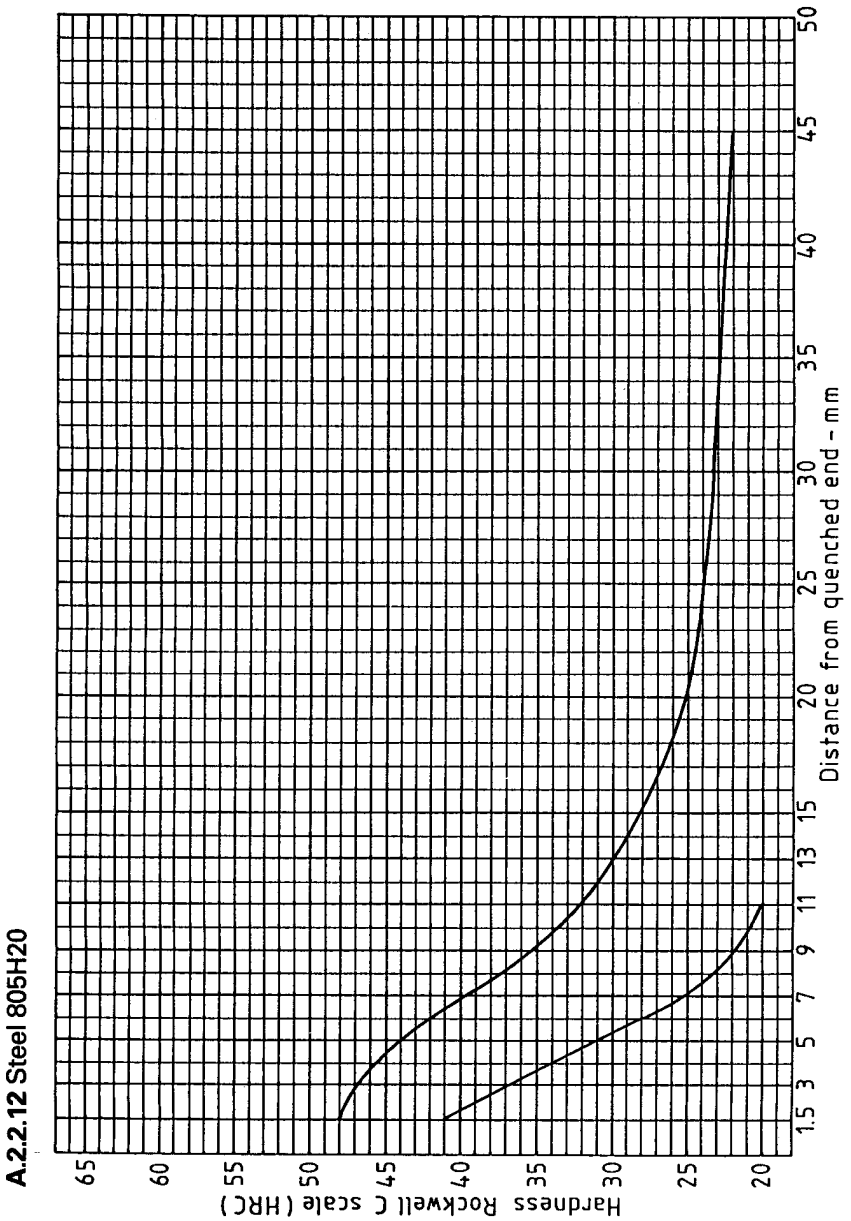




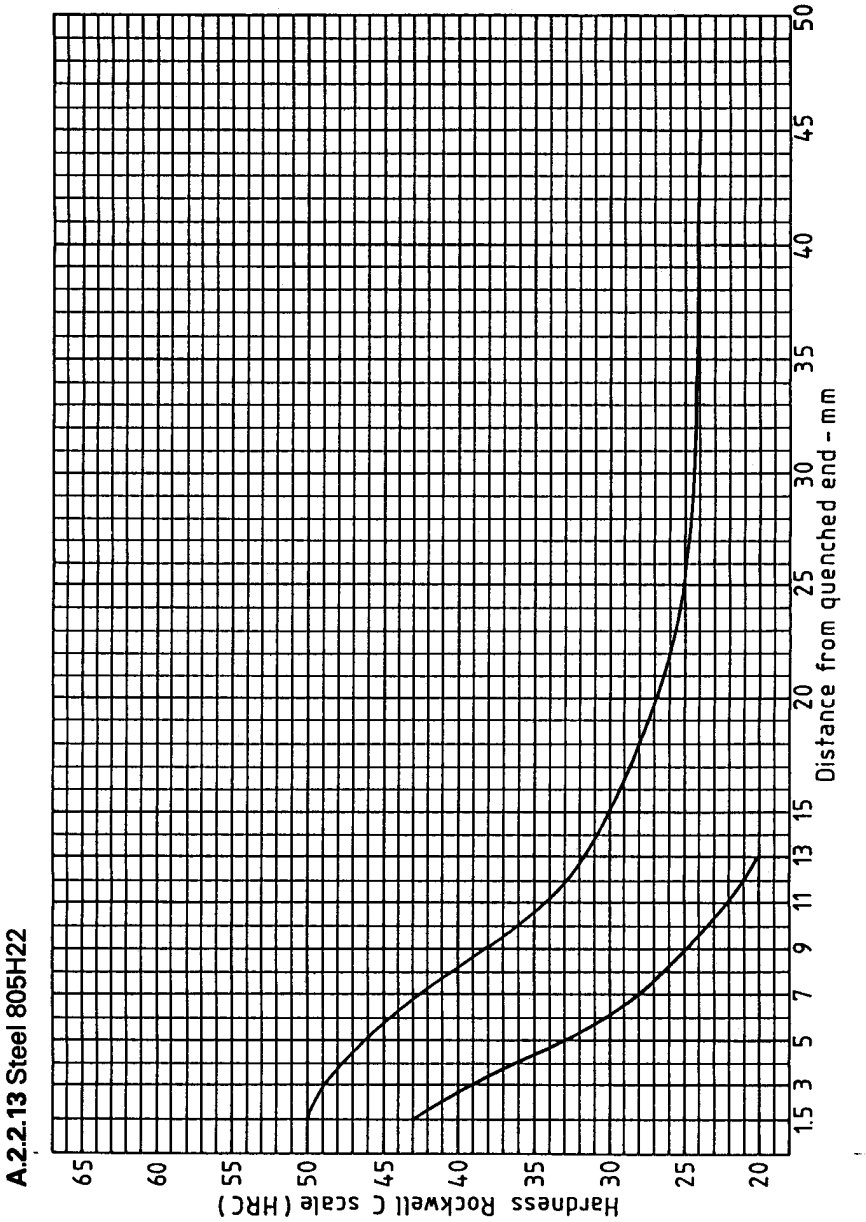
A.2.2.10 Steel 708H20



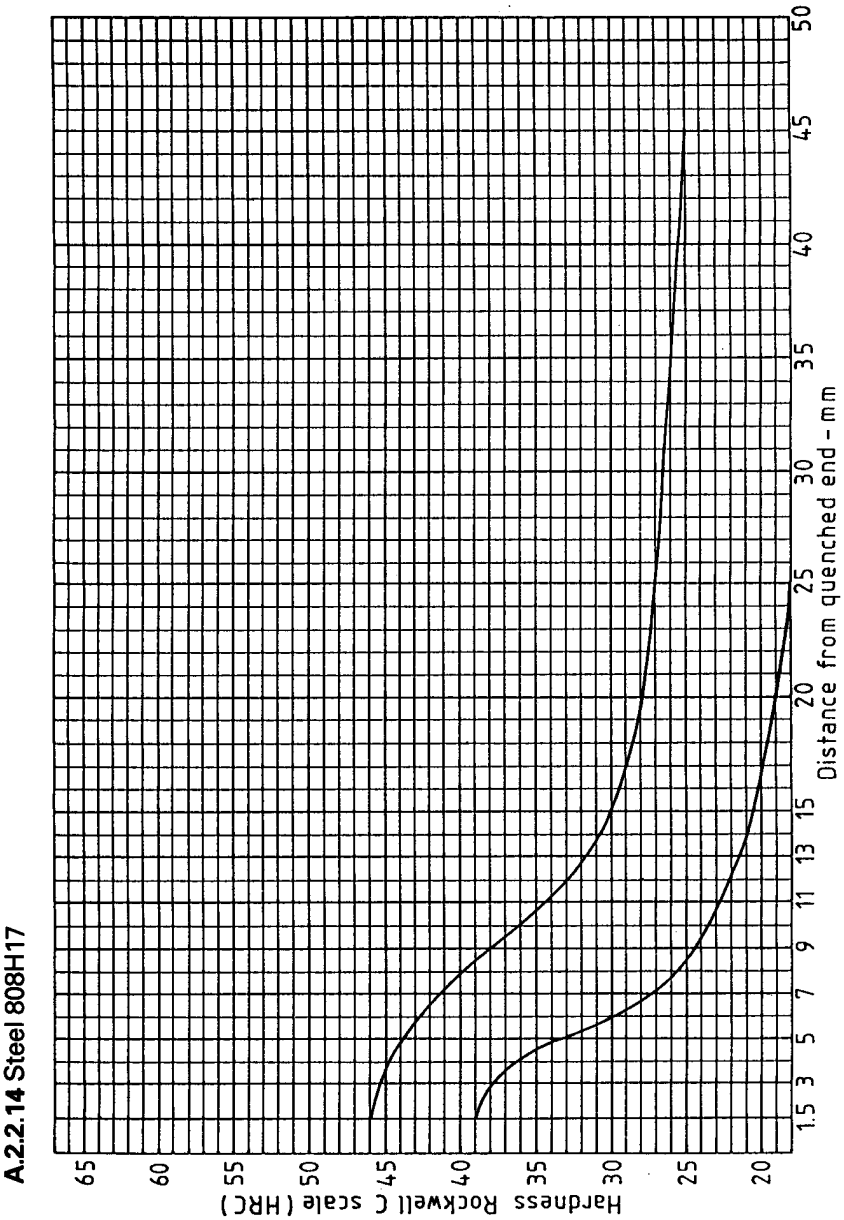
A.2.2.11 Steel 805H17



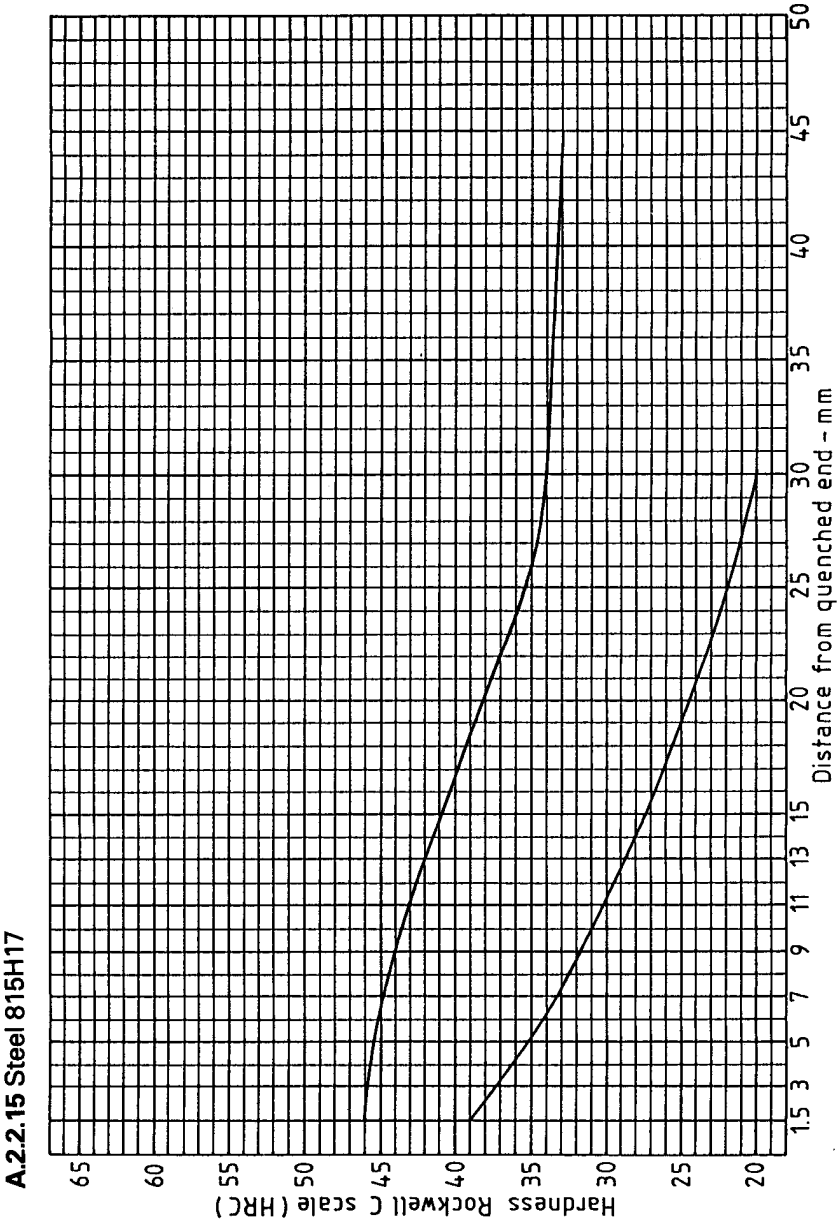
A.2.2.12 Steel 805H20



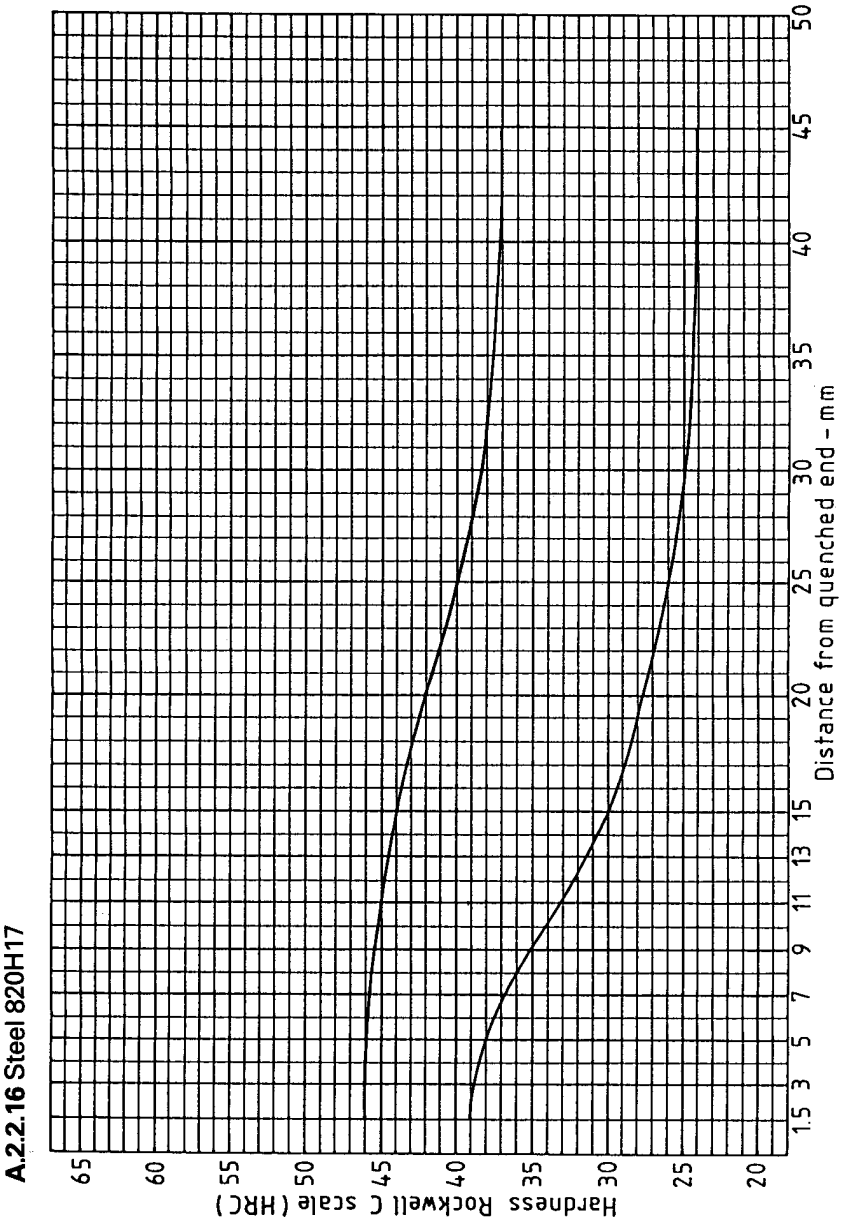
A.2.2.13 Steel 805H22



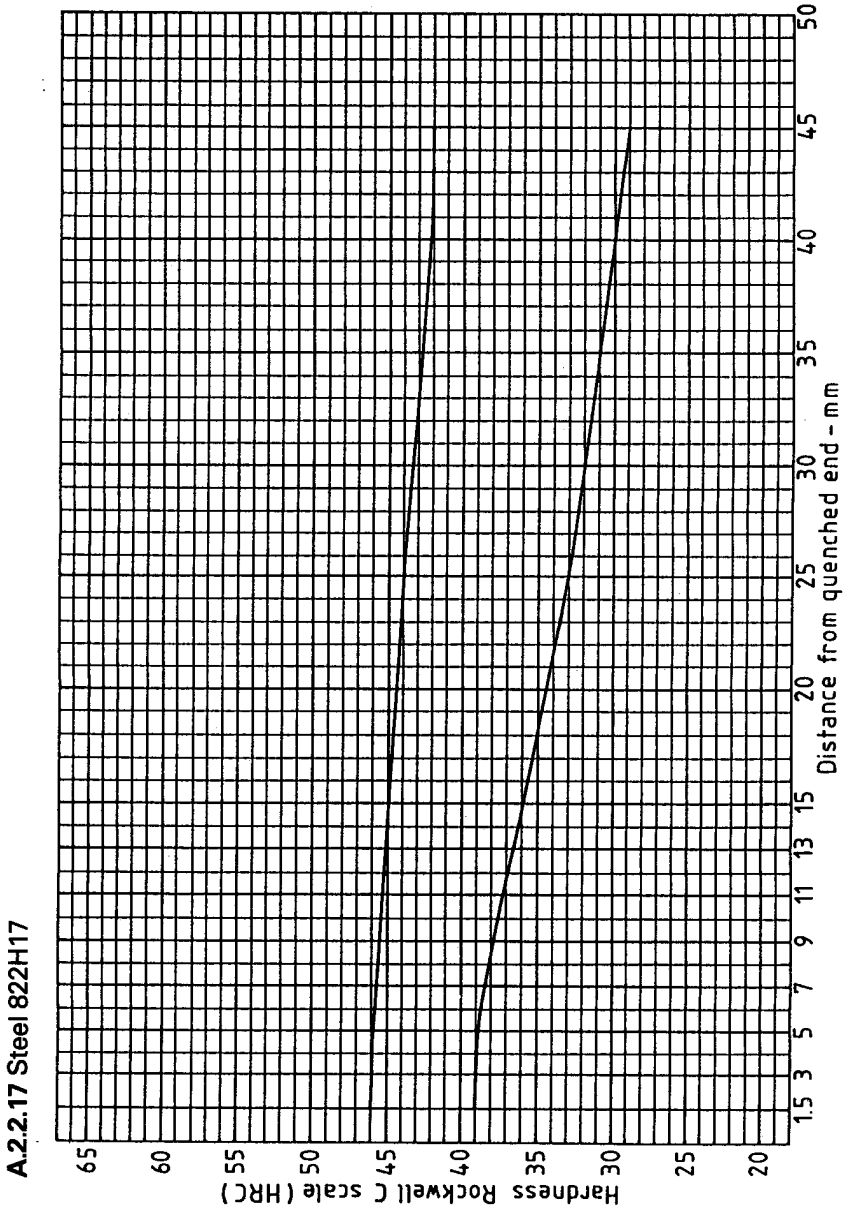
A.2.2.14 Steel 808H17



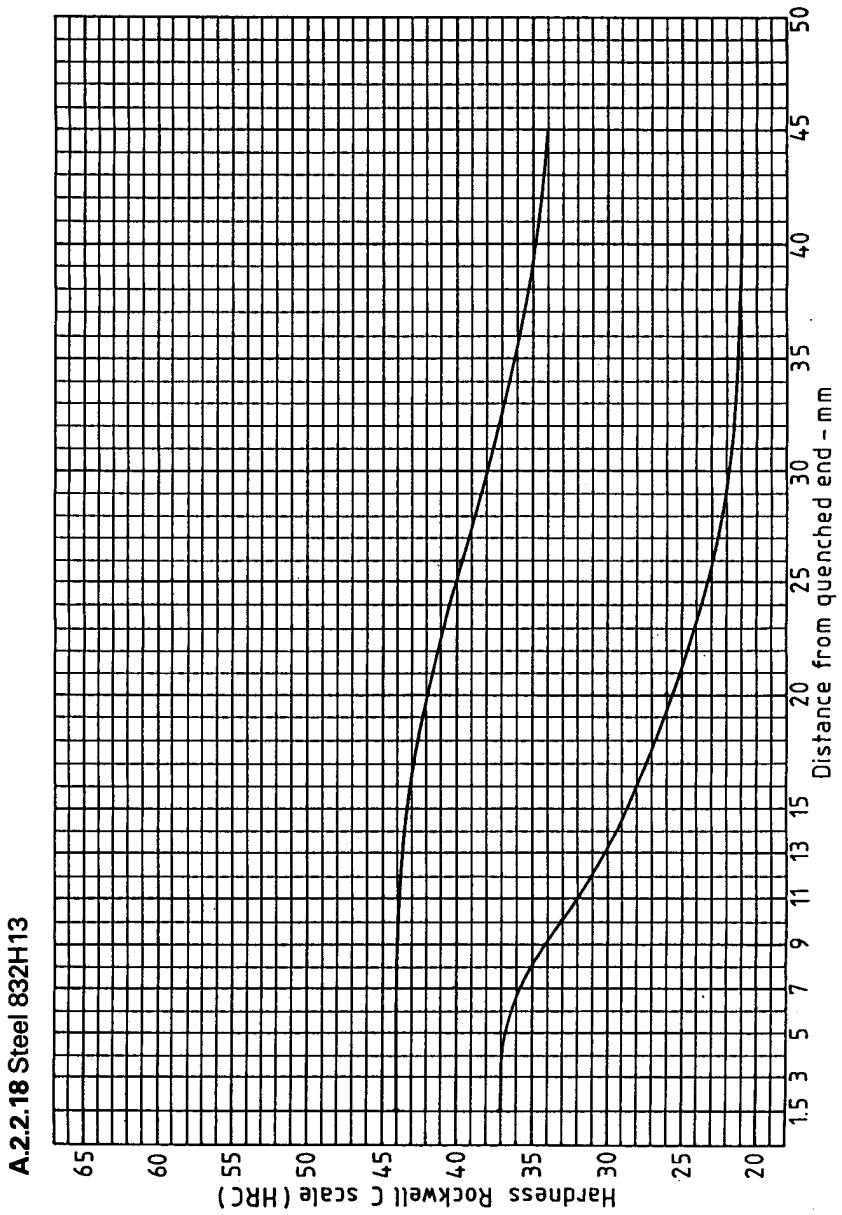
A.2.2.15 Steel 815H17



A.2.2.16 Steel 820H17

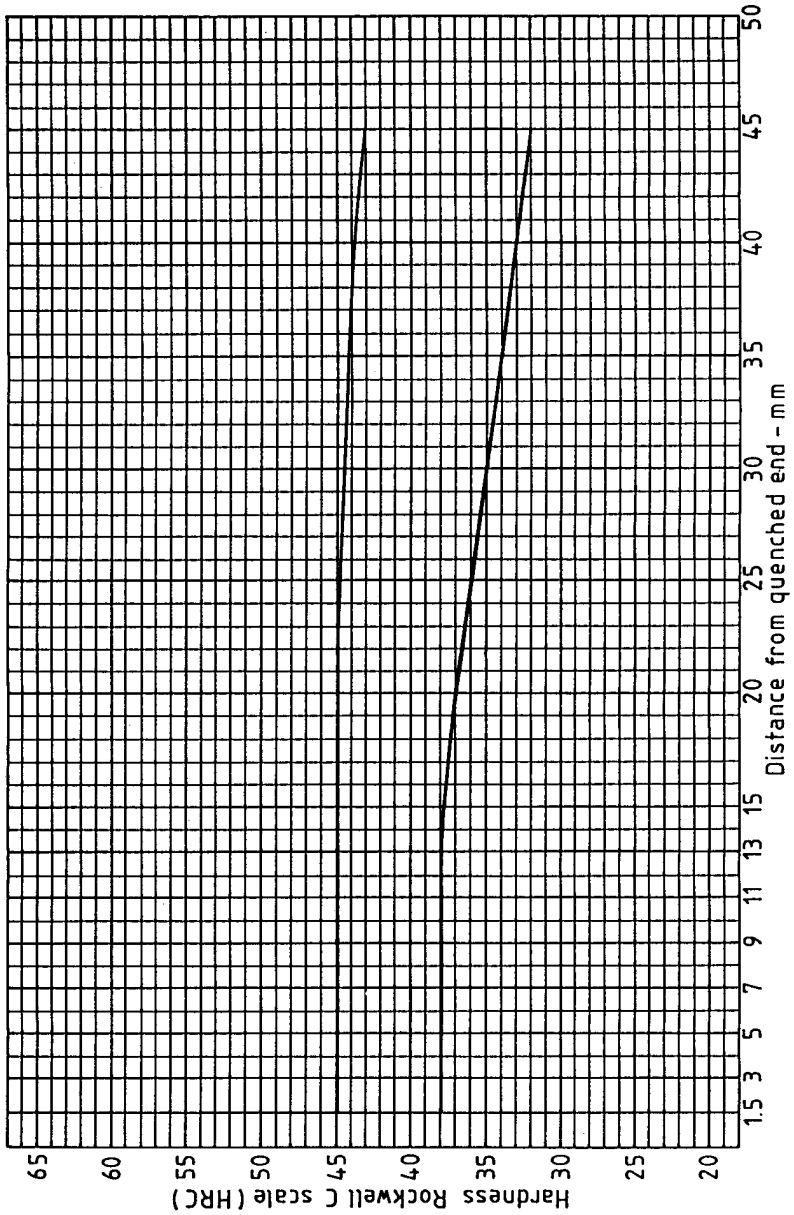


A.2.2.17 Steel 822H17



A.2.2.18 Steel 832H13

A.2.2.19 Steel 835H15



Appendix B

Deoxidation of steel (excluding stainless steels)

B.1 Carbon steel

B.1.1 *General.* Carbon steel is manufactured in a variety of ways and certain features affect the ingot structure and relative uniformity of composition. The method of deoxidation is of particular importance in this respect and this should be recognized when considering the application of carbon steels.

There are three fundamental conditions of supply which are available within the following broad limits and the purchaser should state his requirements on the order.

Steel for forgings and drop forgings are required to be killed, see **1.6.3.1.**

B.1.2 *Killed steel.* Killed steel can be provided over the whole carbon range. Generally silicon killed steel shall contain 0.10 % to 0.40 % silicon and if fine grained steel is required, combined silicon and aluminium deoxidation is generally used. Killed steels can also be supplied with lower silicon contents. In these cases, other deoxidation practices, e.g. vacuum degassing and treatment with aluminium, can be used when the carbon content is less than 0.50 %.

A stabilized steel is usually an aluminium killed steel with sufficient aluminium to give minimal strain-ageing properties in the final product. Elements other than aluminium can be used to obtain these properties, but their use is not general.

B.1.3 *Semi-killed or balanced steel.* Semi-killed or balanced steels are generally only made in carbon ranges below 0.50 %, where the application may be less stringent than for killed steels. Sufficient deoxidants are added to prevent the formation of a rimmed steel structure.

B.1.4 *Rimmed steel.* Rimmed steels are normally restricted to a carbon content of less than 0.25 %, and to a manganese content of less than 0.70 %. Deoxidants are only added to these steels to control the rimming action.

B.2 Alloy steel. Alloy steels are required to be killed and the silicon content shall be within the range 0.10 % to 0.35 %.

Publication(s) referred to

BS 29	Specification for carbon steel forgings above 150 mm ruling section
BS 131	Notched bar tests Part 1 The Izod impact test of metals
BS 240	Method for Brinell hardness test and for verification of Brinell hardness testing machines
BS 427	Method for Vickers hardness test and for verification of Vickers hardness testing machines
BS 891	Methods for hardness test (Rockwell method) and for verification of hardness testing machines (Rockwell method)
BS 970	Specification for wrought steels for mechanical and allied engineering purposes Part 3[1)] Bright bars for general engineering purposes
BS 1134	Assessment of surface texture Part 1 Methods and instrumentation
BS 1837	Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys
BS 4114	Specification for dimensional and quantity tolerances for steel drop and press forgings and for upset forgings made on horizontal forging machines
BS 4437	Method for determining hardenability of steel by end quenching (Jominy test)
BS 4490	Methods for micrographic determination of the grain size of steel
BS 4670	Specification for alloy steel forgings
BS 5046	Method for the estimation of equivalent diameters in the heat treatment of steel
BS 5903	Method for determination of resistance to intergranular corrosion of austenitic stainless steels: copper sulphate-sulphuric acid method (Moneypenny Strauss test)
BS 6722	Recommendations for dimensions of metallic materials
BS EN 10002	Tensile testing of metallic materials Part 1 Method of test at ambient temperature
BS EN 10045	Charpy impact test on metallic materials Part 1 Test method (V- and U-notches)
BS EN 10083[1)]	Quenched and tempered steels Part 1[1)] Technical delivery conditions for special steels Part 2[1)] Technical delivery conditions for unalloyed quality steels
Handbook 19	Methods for the sampling and analysis of iron, steel and other ferrous metals

[1)]Referred to in the foreword only.

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