

Case hardening steels — Technical delivery conditions



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The European Standard EN 10084:1998 has the status of a
British Standard

ICS 77.140.10

National foreword

This British Standard is the English language version of EN 10084:1998. It partially supersedes BS 970-1:1996 by replacing Section 4. This standard should be used in preference to BS 970-1 Section 4 wherever possible until an amendment of BS 970 has been carried out.

A review is being carried out by the Technical Committee with the aim of deciding the best way of carrying out appropriate amendments to BS 970-1 due to the fact that it will be partially superseded by several individual European Standards over the next two years.

National annex NA describes steels used in the United Kingdom but not included in the European Standard.

The UK participation in its preparation was entrusted to Technical Committee ISE/31, Wrought steels, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

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English version

Case hardening steels — Technical delivery conditons

Aciers pour cémentation —
Conditions techniques de livraison

Einsatzstähle —
Technische Lieferbedingungen

This European Standard was approved by CEN on 27 March 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 23, Steels for heat treatment, alloy steels and free-cutting steels — Qualities, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 1998, and conflicting national standards shall be withdrawn at the latest by October 1998.

The United Kingdom issues a non-conflicting national addition which describes a steel used in the United Kingdom but not included in this European Standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

1.1 This European Standard gives the technical delivery requirements for:

- semi-finished products, hot formed, for example blooms, billets, slabs (see notes 2 and 3);
- bars (see note 2);
- rod;
- wide flats;
- hot-rolled sheet/plate and strip;
- hammer and drop forgings (see note 2).

manufactured from the case hardening unalloyed or alloyed steels (see note 4) listed in Table 3 and supplied in one of the heat treatment conditions given for the different types of products in Table 1, lines 2 to 7 and in one of the surface conditions given in Table 2.

The steels are in general intended for the fabrication of case-hardened (see clause 3) machine parts.

NOTE 1 EURONORMS or European Standards relating to steels complying with the requirements for the chemical composition in Table 3 but which are supplied in other product forms or treatment conditions than given above or are intended for special applications, and EURONORMS or European Standards for similar steel grades are listed in annex B.

NOTE 2 Hammer-forged semi-finished products (blooms, billets, slabs, etc.) and hammer-forged bars are included under semi-finished products or bars and not under the term "hammer and drop forgings".

NOTE 3 Special agreements shall be made when ordering undeformed continuously cast semi-finished products.

NOTE 4 In accordance with EN 10020, the steels covered by this European Standard are special steels.

1.2 In special cases variations in these technical delivery requirements or additions to them may form the subject of an agreement at the time of enquiry and order (see annex A).

1.3 In addition to the specifications of this European Standard, the general technical delivery requirements of EN 10021 are applicable, unless otherwise specified.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 10003-1, *Metallic materials — Brinell hardness test — Part 1: Test method.*

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

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

EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

EN 10027-2, *Designation systems for steel — Part 2: Numerical system.*

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

EN 10079, *Definition of steel products.*

EN 10109-1, *Metallic materials — Hardness test — Part 1: Rockwell test (scales A, B, C, D, E, F, G, H, K) and Rockwell superficial test (scales 15N, 30N, 45N, 15T, 30T and 45T).*

EN 10163-2, *Delivery requirements for surface condition of hot rolled steel plates, wide flats and sections — Part 2: Plates and wide flats.*

EN 10204, *Metallic products — Types of inspection documents (includes amendment A1:1995).*

EN 10221, *Surface quality classes for hot-rolled bars and rods — Technical delivery conditions.*

CR 10260, *ECISS IC 10 — Designation systems for steel — Additional symbols for steel names.*

EN ISO 377, *Steel and steel products — Location and preparation of test pieces for mechanical testing.*

EURONORM 23, *End quench hardenability test for steel (Jominy test).¹⁾*

EURONORM 103, *Microscopic determination of the ferritic or austenitic grain size of steels.¹⁾*

ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition.*

DIN 50602:1985, *Metallographic examination — Microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions.*

NF A 04-106:1984, *Iron and steel — Methods of determination of non metallic inclusions in wrought steel — Part II: Micrographic method using standard diagrams.*

SS 111116:1987, *Steel — Methods for assessment of the content of non-metallic inclusions — Microscopic methods — Jernkontoret's inclusion chart II for the assessment of non-metallic inclusions.*

3 Definitions

For the purpose of this European Standard the following definition applies in addition to the definitions in EN 10020, EN 10021, EN 10052, EN 10079, EN ISO 377 and ISO 14284:

3.1

case-hardening steels

steels with a relatively low carbon content which are intended for carburizing or carbonitriding and subsequent hardening; such steels, after treatment, are characterized by a high hardness surface layer and a tough core

¹⁾ It may be agreed at the time of ordering, until this EURONORM has been adopted as a European Standard, that either this EURONORM or a corresponding national standard should be applied.

4 Classification and designation

4.1 Classification

All steels covered by this European Standard are classified according to EN 10020. Steel grades C10E, C10R, C15E, C15R, C16E and C16R are non-alloy special steels. All other steels covered by this European Standard are alloy special steels.

4.2 Designation

4.2.1 Steel names

For the steel grades covered by this European Standard, the steel names as given in Tables 3, 5 and 6 are allocated in accordance with EN 10027-1 and CR 10260.

4.2.2 Steel numbers

For the steel grades covered by this European Standard, the steel numbers as given in Tables 3, 5 and 6 are allocated in accordance with EN 10027-2.

5 Information to be supplied by the purchaser

5.1 Mandatory information

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

- a) the quantity to be delivered;
- b) the designation of the product form (e.g. round or square);
- c) the number of the dimensional standard;
- d) the dimensions and tolerances on dimensions and shape and, if applicable, letters denoting relevant special tolerances;
- e) the number of this European Standard (EN 10084);
- f) steel name or steel number (see 4.2);
- g) if appropriate, the symbol for the heat-treatment condition at delivery (see 6.4.2 and Table 1);
- h) if appropriate, the symbol for the surface condition at delivery (see 6.4.3 and Table 2);
- i) the standard designation for a test report (2.2) or, if required, any other type of inspection document in accordance with EN 10204 (see 8.1).

EXAMPLE:

20 rounds EURONORM 60 - 40 × 8000

EN 10084 - 20MnCr5+A+BC

EN 10204 - 2.2

or:

20 rounds EURONORM 60 - 40 × 8000

EN 10084 - 1.7147+A+BC

EN 10204 - 2.2

5.2 Options

A number of options are specified in this European Standard and listed below. If the purchaser does not indicate his wish to implement one of these options, the supplier shall supply in accordance with the basis specification of this European Standard (see 5.1).

- a) any requirement concerning minimum reduction ratio of rolled and forged products (see 6.3 and A.4);
- b) any special requirement on grain size (see 7.3.1 and 8.2.2);
- c) any requirement concerning determination of non-metallic inclusion content (see 7.3.2, Tables 8 to 10, A.1 and annex D),
- d) any requirement for internal soundness (see 7.4 and A.2),
- e) any requirement relating to surface quality (see 7.5.3),
- f) any requirement concerning suitability of bars and rod for bright drawing (see 7.5.4),
- g) any requirement relating to removal of surface defects (see 7.5.5),
- h) any requirement concerning special marking of the products (see clause 9 and A.5),
- i) any verification of the product analysis (see Table 12 and A.3).

6 Manufacturing process

6.1 Melting process

The type of melting process is left to the discretion of the manufacturer.

6.2 Deoxidation

All steels shall be killed.

6.3 Manufacture of the product

The manufacturing process route of the product shall be at the manufacturer's discretion.

For minimum reduction ratio of rolled and forged products see A.4.

6.4 Heat-treatment condition and surface finish at the time of delivery

6.4.1 Normal condition at delivery

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

6.4.2 Particular heat-treatment condition

If so agreed at the time of enquiry and order, the products shall be delivered in one of the heat-treatment conditions given in Table 1, lines 3 to 7.

6.4.3 Particular surface condition

If so agreed at the time of enquiry and order, the products shall be supplied in one of the special surface conditions given in lines 3 to 6 of Table 2.

6.5 Cast separation

The products shall be delivered separated by cast.

7 Requirements

7.1 Chemical composition, hardness and hardenability

7.1.1 Table 1 gives a survey on combinations of usual heat-treatment conditions at delivery, product forms and requirements according to Tables 3 to 7 (chemical composition, hardenability, maximum hardness, hardness range).

7.1.2 Where the steel is ordered according to Table 3 (designation without hardenability index) the requirements for chemical composition and hardness cited in Table 1, column 9, apply as appropriate for the particular heat-treatment condition. In this case the values of hardenability given in Table 5 are for guidance purposes only.

7.2 Technological properties

7.2.1 Machinability

All steels are machinable in the conditions "annealed to maximum hardness requirements", "treated to hardness range" and "treated to ferrite/pearlite structure and hardness range".

Where improved machinability is required, the grades with a specified sulfur range should be ordered. (see also Table 3, footnote 3.)

7.2.2 Shearability of semi-finished products and bars

7.2.2.1 Under suitable shearing conditions (preheating, application of blades with a profile adapted to that of the product, etc.) all steels are shearable in the condition "annealed to maximum hardness requirements".

7.2.2.2 The steel types 28Cr4, 28CrS4, 20MnCr5, 20MnCrS5, 22CrMoS3-5, 20MoCr3, 20MoCrS3, 20MoCr4, 20MoCrS4, 16NiCr4, 16NiCrS4, 18NiCr5-4, 17CrNi6-6, 15NiCr13, 17NiCrMo6-4, 17NiCrMoS6-4, 20NiCrMoS6-4 and 18CrNiMo7-6 and the corresponding grades with requirements on hardenability (see Tables 5 and 6), are, under suitable conditions, also shearable when supplied in the "treated to improve shearability" condition with the hardness requirements given in Table 7.

7.2.2.3 The unalloyed steels and the steels 17Cr3, 17CrS3, 16MnCr5, 16MnCrS5, 16MnCrB5, 18CrMo4, 18CrMoS4, 10NiCr5-4, 20NiCrMo2-2, 20NiCrMoS2-2 and the corresponding grades with requirements on hardenability (see Tables 5 and 6) are shearable in the untreated condition under suitable conditions.

7.3 Structure

7.3.1 Unless otherwise agreed, the steel, when tested in accordance with one of the methods described in EURONORM 103, shall show an austenitic grain size of 5 to 8. The grain structure shall be considered satisfactory if 70 % of the area is within the specified size limits.

7.3.2 The steels shall have a degree of cleanliness corresponding to the special steel quality (see A.1, annex D and Tables 8 to 10).

7.4 Internal soundness

Requirements for internal soundness may be agreed upon at the time of enquiry and order, e.g. on the basis of non-destructive tests (see A.2).

7.5 Surface quality

7.5.1 All products shall have a surface finish appropriate to the forming processes applied.

7.5.2 Minor surface imperfections which may occur also under normal manufacturing conditions, such as scores originating from rolled-in scale in the case of hot-rolled products, shall not be regarded as defects.

7.5.3 Where appropriate, requirements relating to the surface quality of the products shall be agreed on at the time of enquiry and order; in the case of hot-rolled bars and rods with reference to EN 10221, in the case of flat products with reference to EN 10163-2.

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

7.5.4 If suitability of bars, wide flats and rod for bright drawing is required, this shall be agreed at the time of enquiry and order.

7.5.5 The removal of surface defects by welding is only permitted with the approval of the customer or his representative.

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

7.6 Dimensions, tolerances on dimensions and shape

The nominal dimensions, tolerances on dimensions and shape tolerances for the product shall be agreed at the time of enquiry and order, if possible, with reference to the dimensional standards applicable (see annex C).

8 Inspection and testing

8.1 Types and contents of inspection documents

8.1.1 Products complying with this European Standard shall be ordered and delivered with one of the inspection documents as specified in EN 10204. The type of document shall be agreed upon at the time of enquiry and order. If the order does not contain any specification of this type, a test report shall be issued.

8.1.2 If, in accordance with the agreements made at the time of enquiry and order, a test report is to be issued, it shall contain the following information:

- the confirmation that the material complies with the requirements of the order;
- the results of the cast analysis for all the elements specified in Table 3 for the steel grade concerned.

8.1.3 If, in accordance with the order agreements, an inspection certificate or inspection report is to be issued, the specific tests described in 8.2 shall be carried out and the results shall be confirmed in the inspection document.

In addition, the inspection document shall include the following information:

- a) the manufacturer's results for the cast analysis of all elements specified in Table 3 for the steel grade concerned;
- b) the results of inspections and tests ordered as a result of supplementary requirements (see annex A);
- c) the symbol letters or numbers relating the inspection documents, test pieces and products to each other.

8.2 Specific inspection and testing

8.2.1 Verifications of the hardenability and hardness

8.2.1.1 For steels being ordered without hardenability requirements, i.e. without the symbol +H, +HH or +HL in the designation, the hardness requirements given for the relevant heat-treatment condition in Table 1, column 9, subheading 2, shall be verified.

For steels being ordered with the symbol +H, +HH or +HL in the designation (see Tables 5 and 6), unless otherwise agreed, only the hardenability requirements according to Table 5 or 6 shall be verified. If so agreed at the time of enquiry and order, verification of hardenability may be provided by calculation. The calculation method shall also be agreed upon in this case.

8.2.1.2 The amount of testing, the sampling conditions and the test methods to be applied for the verification of the requirements shall be in accordance with the prescriptions in Table 12.

8.2.2 Verification of the grain size

In case the verification of the fine grain structure is specified, the method for determination of grain size according to EURONORM 103, the amount of testing and the testing conditions shall be agreed at the time of enquiry and order.

8.2.3 Visual and dimensional inspection

A sufficient number of products shall be inspected to ensure compliance with the specification.

8.2.4 Retests

See EN 10021.

9 Marking

The manufacturer shall mark the products or the bundles or boxes in a suitable way so that it is possible to determine the cast, the steel grade and the origin of the delivery (see A.5).

Table 1 — Combinations of usual heat-treatment conditions at delivery, product forms and requirements according to Tables 3 to 7

1	2	3	4				7	8	9			10			11
			semi-finished products	bars	rod	flat products			hammer and drop forgings	Applicable requirements if the steel is ordered with the designation given in			Table 5 or 6		
1	Heat-treatment condition at delivery	Symbol	X = Applicable for						Table 3	1	2	1	2	3	
2	Untreated	None or + U	X	X	X	X	X	—	—	—	—	—	—	—	
3	Treated to improve shearability	+ S	X	X	—	—	—	—	—	—	—	—	—	—	
4	Annealed to maximum hardness requirements	+ A	X	X	X	X	X	—	Chemical composition according to Tables 3 and 4	Brinell hardness according to Table 7	Column + S	As in column 9 (see footnote 2 to Table 3)	Hardenability values according to Table 5 or 6	Observe also supplementary requirements given in annex A	
5	Treated to hardness range	+ TH	—	X	X	X	X	—	Column + A						
6	Treated to ferrite-pearlite structure and hardness range	+ FP	—	X	—	—	—	—	Column + TH						
									Column + FP						
7	Others	Other treatment conditions, for example certain annealing conditions to achieve a certain structure, may be agreed at the time of enquiry and order. The condition "annealed to achieve a spheroidization of the carbides", as required for cold heading and cold extrusion, is covered in EURONORM 119.													



Table 2 — Surface condition at delivery

1	2	3	4	5	6	7	8	9	10
1	Surface condition at delivery	Symbol	× = in general applicable for						Notes
			semi-finished products such as blooms billets	bars	rods	flat products	products and drop forgings (see 1.1, note 2)		
2	Unless otherwise agreed	As hot worked	None or + HW	× ¹⁾	×	×	×		
3	Particular conditions supplied by agreement	HW +pickled	+ PI	—	—	×	×	—	3)
4		HW + blast cleaned	+ BC	×	×	×	×	×	
5		HW + rough machined ²⁾		—	×	×	—	×	

1) The term "hot worked" includes in the case of semi-finished products also the continuously cast condition.
2) Until the term "rough machined" is defined by, for example, machining allowances etc., the details are to be agreed at the time of enquiry and order.
3) In addition certain surface treatments like oiled or limed or phosphated may be agreed.

Table 3 — Steel grades and chemical composition (cast analysis)

Steel designation		% by mass ¹⁾²⁾³⁾								
name	number	C	Si max.	Mn	P max	S	Cr	Mo	Ni	B
C10E	1.1121	0,07 to 0,13	0,40	0,30 to 0,60	0,035	≤ 0,035				
C10R	1.1207	0,07 to 0,13	0,40	0,30 to 0,60	0,035	0,020 to 0,040				
C15E	1.1141	0,12 to 0,18	0,40	0,30 to 0,60	0,035	≤ 0,035				
C15R	1.1140	0,12 to 0,18	0,40	0,30 to 0,60	0,035	0,020 to 0,040				
C16E	1.1148	0,12 to 0,18	0,40	0,60 to 0,90	0,035	≤ 0,035				
C16R	1.1208	0,12 to 0,18	0,40	0,60 to 0,90	0,035	0,020 to 0,040				
17Cr3	1.7016	0,14 to 0,20	0,40	0,60 to 0,90	0,035	≤ 0,035	0,70 to 1,00			
17CrS3	1.7014					0,020 to 0,040				
28Cr4	1.7030	0,24 to 0,31	0,40	0,60 to 0,90	0,035	≤ 0,035	0,90 to 1,20			
28CrS4	1.7036					0,020 to 0,040				
16MnCr5	1.7131	0,14 to 0,19	0,40	1,00 to 1,30	0,035	≤ 0,035	0,80 to 1,10			
16MnCrS5	1.7139					0,020 to 0,040				
16MnCrB5	1.7160	0,14 to 0,19	0,40	1,00 to 1,30	0,035	≤ 0,035	0,80 to 1,10			0,0008 to 0,0050 ⁴⁾

Table 3 — Steel grades and chemical composition (cast analysis) (continued)

Steel designation		% by mass ¹⁾²⁾³⁾								
name	number	C	Si max.	Mn	P max.	S	Cr	Mo	Ni	B
20MnCr5	1.7147	0,17 to 0,22	0,40	1,10 to 1,40	0,035	≤ 0,035	1,00 to 1,30			
20MnCrS5	1.7149					0,020 to 0,040				
18CrMo4	1.7243	0,15 to 0,21	0,40	0,60 to 0,90	0,035	≤ 0,035	0,90 to 1,20	0,15 to 0,25		
18CrMoS4	1.7244					0,020 to 0,040				
22CrMoS3-5	1.7333	0,19 to 0,24	0,40	0,70 to 1,00	0,035	0,020 to 0,040	0,70 to 1,00	0,40 to 0,50		
20MoCr3	1.7320	0,17 to 0,23	0,40	0,60 to 0,90	0,035	≤ 0,035	0,40 to 0,70	0,30 to 0,40		
20MoCrS3	1.7319					0,020 to 0,040				
20MoCr4	1.7321	0,17 to 0,23	0,40	0,70 to 1,00	0,035	≤ 0,035	0,30 to 0,60	0,40 to 0,50		
20MoCrS4	1.7323					0,020 to 0,040				
16NiCr4	1.5714	0,13 to 0,19	0,40	0,70 to 1,00	0,035	≤ 0,035	0,60 to 1,00		0,80 to 1,10	
16NiCrS4	1.5715					0,020 to 0,040				
10NiCr5-4	1.5805	0,07 to 0,12	0,40	0,60 to 0,90	0,035	≤ 0,035	0,90 to 1,20		1,20 to 1,50	
18NiCr5-4	1.5810	0,16 to 0,21	0,40	0,60 to 0,90	0,035	≤ 0,035	0,90 to 1,20		1,20 to 1,50	
17CrNi6-6	1.5918	0,14 to 0,20	0,40	0,50 to 0,90	0,035	≤ 0,035	1,40 to 1,70		1,40 to 1,70	
15NiCr13	1.5752	0,14 to 0,20	0,40	0,40 to 0,70	0,035	≤ 0,035	0,60 to 0,90		3,00 to 3,50	
20NiCrMo2-2	1.6523	0,17 to 0,23	0,40	0,65 to 0,95	0,035	≤ 0,035	0,35 to 0,70	0,15 to 0,25	0,40 to 0,70	
20NiCrMoS2-2	1.6526					0,020 to 0,040				
17NiCrMo6-4	1.6566	0,14 to 0,20	0,40	0,60 to 0,90	0,035	≤ 0,035	0,80 to 1,10	0,15 to 0,25	1,20 to 1,50	
17NiCrMoS6-4	1.6569					0,020 to 0,040				
20NiCrMoS6-4	1.6571	0,16 to 0,23	0,40	0,50 to 0,90	0,035	0,020 to 0,040	0,60 to 0,90	0,25 to 0,35	1,40 to 1,70	
18CrNiMo7-6	1.6587	0,15 to 0,21	0,40	0,50 to 0,90	0,035	≤ 0,035	1,50 to 1,80	0,25 to 0,35	1,40 to 1,70	
14NiCrMo13-4	1.6657	0,11 to 0,17	0,40	0,30 to 0,60	0,035	≤ 0,035	0,80 to 1,10	0,10 to 0,25	3,00 to 3,50	

¹⁾ Elements not quoted in this table shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions should be taken to prevent the addition from scrap or other material used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

²⁾ Where requirements are made on hardenability (see Tables 5 and 6), slight deviations from the limits for the cast analysis are permitted, except for phosphorus and sulfur; these deviations shall, however, not exceed in the case of carbon ± 0,01 % and in all other cases the values acc. to Table 4.

³⁾ Steels with improved machinability as a result of the addition of lead or higher sulfur contents, depending on the manufacturing process up to around 0,100 % S (including controlled sulfide and oxide formation, e.g. calcium treatment), may be supplied on request. In this case, the upper limit of the manganese content may be increased by 0,15 %.

⁴⁾ Boron is in this case added not for increase of hardenability but to improve the toughness of the case hardened zone.

Table 4 — Permissible deviations between the product analysis and the limiting values given in Table 3 for the cast analysis

Element	Permissible maximum content in the cast analysis % by mass	Permissible deviation ¹⁾ % by mass
C	≤ 0,31	± 0,02
Si	≤ 0,40	+ 0,03
Mn	≤ 1,00	± 0,04
	> 1,00 ≤ 1,40	± 0,05
P	≤ 0,035	+ 0,005
S	≤ 0,040	+ 0,005 ²⁾
Cr	≤ 1,80	± 0,05
Mo	≤ 0,30	± 0,03
	> 0,30 ≤ 0,50	± 0,04
Ni	≤ 2,00	± 0,05
	> 2,00 ≤ 3,50	± 0,07
B	≤ 0,0050	± 0,0005

¹⁾ ± means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in Table 3, but not both at the same time.

²⁾ For steels with a specified sulfur range (0,020 to 0,040 % according to cast analysis), the permissible deviation is ± 0,005 %.

Table 5 — Hardness limits for steel types with specified (normal) hardenability
(H-grades: see 7.1)

Steel designation		Limits of range	Hardness HRC at a distance from quenched end of test piece (in millimetres) of												
name	number		1,5	3	5	7	9	11	13	15	20	25	30	35	40
17Cr3+H	1.7016+H	max.	47	44	40	33	29	27	25	24	23	21	—	—	—
17CrS3+H	1.7014+H	min.	39	35	25	20	—	—	—	—	—	—	—	—	—
28Cr4+H	1.7030+H	max.	53	52	51	49	45	42	39	36	33	30	29	28	27
28CrS4+H	1.7036+H	min.	45	43	39	29	25	22	20	—	—	—	—	—	—
16MnCr5+H	1.7131+H	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
16MnCrS5+H	1.7139+H	min.	39	36	31	28	24	21	—	—	—	—	—	—	—
16MnCrB5+H	1.7160+H	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
		min.	39	36	31	28	24	21	—	—	—	—	—	—	—
20MnCr5+H	1.7147+H	max.	49	49	48	46	43	42	41	39	37	35	34	33	32
20MnCrS5+H	1.7149+H	min.	41	39	36	33	30	28	26	25	23	21	—	—	—
18CrMo4+H	1.7243+H	max.	47	46	45	42	39	37	35	34	31	29	28	27	26
18CrMoS4+H	1.7244+H	min.	39	37	34	30	27	24	22	21	—	—	—	—	—
22CrMoS3-5+H	1.7333+H	max.	50	49	48	47	45	43	41	40	37	35	34	33	32
		min.	42	41	37	33	31	28	26	25	23	22	21	20	—
20MoCr3+H	1.7320+H	max.	49	47	45	40	35	32	31	30	28	26	25	24	23
20MoCrS3+H	1.7319+H	min.	41	38	34	28	22	20	—	—	—	—	—	—	—
20MoCr4+H	1.7321+H	max.	49	47	44	41	38	35	33	31	28	26	25	24	24
20MoCrS4+H	1.7323+H	min.	41	37	31	27	24	22	—	—	—	—	—	—	—
16NiCr4+H	1.5714+H	max.	47	46	44	42	40	38	36	34	32	30	29	28	28
16NiCrS4+H	1.5715+H	min.	39	36	33	29	27	25	23	22	20	—	—	—	—
10NiCr5-4+H	1.5805+H	max.	41	39	37	34	32	30	—	—	—	—	—	—	—
		min.	32	27	24	22	—	—	—	—	—	—	—	—	—
18NiCr5-4+H	1.5810+H	max.	49	48	46	44	42	39	37	36	34	32	31	31	30
		min.	41	39	35	32	29	27	25	24	21	20	—	—	—
17CrNi6-6+H	1.5918+H	max.	47	47	46	45	43	42	41	39	37	35	34	34	33
		min.	39	38	36	35	32	30	28	26	24	22	21	20	20
15NiCr13+H	1.5752+H	max.	48	48	48	47	45	44	42	41	38	35	34	34	33
		min.	41	41	41	40	38	36	33	30	24	22	22	21	21
20NiCrMo2-2+H	1.6523+H	max.	49	48	45	42	36	33	31	30	27	25	24	24	23
20NiCrMoS2-2+H	1.6526+H	min.	41	37	31	25	22	20	—	—	—	—	—	—	—
17NiCrMo6-4+H	1.6566+H	max.	48	48	47	46	45	44	42	41	38	36	35	34	33
17NiCrMoS6-4+H	1.6569+H	min.	40	40	37	34	30	28	27	26	24	23	22	21	—
20NiCrMoS6-4+H	1.6571+H	max.	49	49	48	48	47	47	46	44	41	39	38	37	36
		min.	41	40	39	36	33	30	28	26	23	21	—	—	—
18CrNiMo7-6+H	1.6587+H	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
		min.	40	40	39	38	37	36	35	34	32	31	30	29	29
14NiCrMo13-4+H	1.6657+H	max.	47	47	46	46	46	46	46	45	43	42	40	39	38
		min.	39	39	37	36	36	36	35	33	31	30	28	27	26

Table 6 — Hardness limits for steel types with restricted hardenability scatterbands (HH- and HL-grades)

Steel designation		Limits of range	Hardness HRC at a distance from quenched end of test piece (in millimetres) of												
name	number		1.5	3	5	7	9	11	13	15	20	25	30	35	40
17Cr3+HH	1.7016+HH	max.	47	44	40	33	29	27	25	24	23	21	—	—	—
17CrS3+HH	1.7014+HH	min.	42	38	30	24	20	—	—	—	—	—	—	—	—
17Cr3+HL	1.7016+HL	max.	44	41	35	29	25	23	21	20	—	—	—	—	—
17CrS3+HL	1.7014+HL	min.	39	35	25	20	—	—	—	—	—	—	—	—	—
28Cr4+HH	1.7030+HH	max.	53	52	51	49	45	42	39	36	33	30	29	28	27
28CrS4+HH	1.7036+HH	min.	48	46	43	36	32	29	26	23	20	—	—	—	—
28Cr4+HL	1.7030+HL	max.	50	49	47	42	38	35	33	30	27	24	23	22	21
28CrS4+HL	1.7036+HL	min.	45	43	39	29	25	22	20	—	—	—	—	—	—
16MnCr5+HH	1.7131+HH	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
16MnCrS5+HH	1.7139+HH	min.	42	39	35	32	29	26	24	22	20	—	—	—	—
16MnCr5+HL	1.7131+HL	max.	44	43	40	37	34	32	30	28	26	25	24	23	22
16MnCrS5+HL	1.7139+HL	min.	39	36	31	28	24	21	—	—	—	—	—	—	—
16MnCrB5+HH	1.7160+HH	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
		min.	42	39	35	32	29	26	24	22	20	—	—	—	—
16MnCrB5+HL	1.7160+HL	max.	44	43	40	37	34	32	30	28	26	25	24	23	22
		min.	39	36	31	28	24	21	—	—	—	—	—	—	—
20MnCr5+HH	1.7147+HH	max.	49	49	48	46	43	42	41	39	37	35	34	33	32
20MnCrS5+HH	1.7149+HH	min.	44	42	40	37	34	33	31	30	28	26	25	24	23
20MnCr5+HL	1.7147+HL	max.	46	46	44	42	39	37	36	34	32	30	29	28	27
20MnCrS5+HL	1.7149+HL	min.	41	39	36	33	30	28	26	25	23	21	—	—	—
18CrMo4+HH	1.7243+HH	max.	47	46	45	42	39	37	35	34	31	29	28	27	26
18CrMoS4+HH	1.7244+HH	min.	42	40	38	34	31	28	26	25	22	20	—	—	—
18CrMo4+HL	1.7243+HL	max.	44	43	41	38	35	33	31	30	27	25	24	23	22
18CrMoS4+HL	1.7244+HL	min.	39	37	34	30	27	24	22	21	—	—	—	—	—
22CrMoS3-5+HH	1.7333+HH	max.	50	49	48	47	45	43	41	40	37	35	34	33	32
		min.	45	44	41	38	36	33	31	30	28	26	25	24	23
22CrMoS3-5+HL	1.7333+HL	max.	47	46	44	42	40	38	36	35	32	31	30	29	28
		min.	42	41	37	33	31	28	26	25	23	22	21	20	—
20MoCr3+HH	1.7320+HH	max.	49	47	45	40	35	32	31	30	28	26	25	24	23
20MoCrS3+HH	1.7319+HH	min.	44	41	38	32	26	24	23	22	20	—	—	—	—
20MoCr3+HL	1.7320+HL	max.	46	44	41	36	31	28	27	26	24	22	21	20	—
20MoCrS3+HL	1.7319+HL	min.	41	38	34	28	22	20	—	—	—	—	—	—	—
20MoCr4+HH	1.7321+HH	max.	49	47	44	41	38	35	33	31	28	26	25	24	24
20MoCrS4+HH	1.7323+HH	min.	44	40	35	32	29	26	24	22	—	—	—	—	—
20MoCr4+HL	1.7321+HL	max.	46	44	40	36	33	31	29	27	24	22	21	20	20
20MoCrS4+HL	1.7323+HL	min.	41	37	31	27	24	22	—	—	—	—	—	—	—
16NiCr4+HH	1.5714+HH	max.	47	46	44	42	40	38	36	34	32	30	29	28	28
16NiCrS4+HH	1.5715+HH	min.	42	39	37	33	31	29	27	26	24	22	21	20	20
16NiCr4+HL	1.5714+HL	max.	44	43	40	38	36	34	32	30	28	26	25	24	24
16NiCrS4+HL	1.5715+HL	min.	39	36	33	29	27	25	23	22	20	—	—	—	—
10NiCr5-4+HH	1.5805+HH	max.	41	39	37	34	32	30	—	—	—	—	—	—	—
		min.	33	29	26	24	21	20	—	—	—	—	—	—	—
10NiCr5-4+HL	1.5805+HL	max.	38	35	32	30	27	25	—	—	—	—	—	—	—
		min.	32	27	24	22	—	—	—	—	—	—	—	—	—
18NiCr5-4+HH	1.5810+HH	max.	49	48	46	44	42	39	37	36	34	32	31	31	30
		min.	44	42	39	36	33	31	29	28	25	24	23	23	22

Table 6 — Hardness limits for steel types with restricted hardenability scatterbands (HH- and HL-grades) (continued)

Steel designation		Limits of range	Hardness HRC at a distance from quenched end of test piece (in millimetres) of												
name	number		1.5	3	5	7	9	11	13	15	20	25	30	35	40
18NiCr5-4+HL	1.5810+HL	max.	46	45	42	40	38	35	33	32	30	28	27	27	26
		min.	41	39	35	32	29	27	25	24	21	20	—	—	—
17CrNi6-6+HH	1.5918+HH	max.	47	47	46	45	43	42	41	39	37	35	34	34	33
		min.	42	41	39	38	36	34	32	30	28	26	25	25	24
17CrNi6-6+HL	1.5918+HL	max.	44	44	43	42	39	38	37	35	33	31	30	29	29
		min.	39	38	36	35	32	30	28	26	24	22	21	20	20
15NiCr13+HH	1.5752+HH	max.	48	48	48	47	45	44	42	41	38	35	34	34	33
		min.	43	43	43	42	40	39	36	34	29	26	26	25	25
15NiCr13+HL	1.5752+HL	max.	46	46	46	45	43	41	38	37	33	31	30	30	29
		min.	41	41	41	40	38	36	33	30	24	22	22	21	21
20NiCrMo2-2+HH	1.6523+HH	max.	49	48	45	42	36	33	31	30	27	25	24	24	23
20NiCrMoS2-2+HH	1.6526+HH	min.	44	41	36	31	27	24	22	21	—	—	—	—	—
20NiCrMo2-2+HL	1.6523+HL	max.	46	44	40	36	31	29	27	26	23	21	20	20	—
20NiCrMoS2-2+HL	1.6526+HL	min.	41	37	31	25	22	20	—	—	—	—	—	—	—
17NiCrMo6-4+HH	1.6566+HH	max.	48	48	47	46	45	44	42	41	38	36	35	34	33
17NiCrMoS6-4+H	1.6569+HL	min.	43	43	40	38	35	33	32	31	29	27	26	25	24
17NiCrMo6-4+HL	1.6566+HL	max.	45	45	44	42	40	39	37	36	33	32	31	30	29
17NiCrMoS6-4+HL	1.6569+HL	min.	40	40	37	34	30	28	27	26	24	23	22	21	—
20NiCrMoS6-4+HH	1.6571+HH	max.	49	49	48	48	47	47	46	44	41	39	38	37	36
		min.	44	43	42	40	38	36	34	32	29	27	26	25	24
20NiCrMoS6-4+HL	1.6571+HL	max.	46	46	45	44	42	41	40	38	35	33	32	31	30
		min.	41	40	39	36	33	30	28	26	23	21	—	—	—
18CrNiMo7-6+HH	1.6587+HH	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
		min.	43	43	42	41	40	40	39	38	36	35	34	33	33
18CrNiMo7-6+HL	1.6587+HL	max.	45	45	45	45	44	43	42	42	40	39	38	37	37
		min.	40	40	39	38	37	36	35	34	32	31	30	29	29
14NiCrMo13-4+HH	1.6657+HH	max.	47	47	46	46	46	46	46	45	43	42	40	39	38
		min.	42	42	40	39	39	39	39	37	35	34	32	31	30
14NiCrMo13-4+HL	1.6657+HL	max.	44	44	43	43	43	43	42	41	39	38	36	35	34
		min.	39	39	37	36	36	36	35	33	31	30	28	27	26

Table 7 — Hardness requirements for products delivered in the conditions “treated to improve shearability” (+S), “annealed to maximum hardness requirements” (+A), “treated to hardness range” (+TH) or “treated to ferrite-pearlite structure and hardness range” (+FP)

Steel designation		Brinell hardness in the condition					
name	number	+S max.	+A max.	+TH min. max.		+FP min. max.	
C10E	1.1121	—	131	—	—	—	—
C10R	1.1207						
C15E	1.1141	—	143	—	—	—	—
C15R	1.1140						
C16E	1.1148	—	156	—	—	—	—
C16R	1.1208						
17Cr3	1.7016	1)	174	—	—	—	—
17CrS3	1.7014						
28Cr4	1.7030	255	217	166	217	156	207
28CrS4	1.7036						
16MnCr5	1.7131	1)	207	156	207	140	187
16MnCrS5	1.7139						
16MnCrB5	1.7160	1)	207	156	207	140	187
20MnCr5	1.7147	255	217	170	217	152	201
20MnCrS5	1.7149						
18CrMo4	1.7243	1)	207	156	207	140	187
18CrMoS4	1.7244						
22CrMoS3-5	1.7333	255	217	170	217	152	201
20MoCr3	1.7320	255	217	160	205	145	185
20MoCrS3	1.7319						
20MoCr4	1.7321	255	207	156	207	140	187
20MoCrS4	1.7323						
16NiCr4	1.5714	255	217	166	217	156	207
16NiCrS4	1.5715						
10NiCr5-4	1.5805	1)	192	147	197	137	187
18NiCr5-4	1.5810	255	223	170	223	156	207
17CrNi6-6	1.5918	255	229	175	229	156	207
15NiCr13	1.5752	255	229	179	229	166	217
20NiCrMo2-2	1.6523	1)	212	161	212	149	194
20NiCrMoS2-2	1.6526						
17NiCrMo6-4	1.6566	255	229	179	229	149	201
17NiCrMoS6-4	1.6569						
20NiCrMoS6-4	1.6571	255	229	179	229	154	207
18CrNiMo7-6	1.6587	255	229	179	229	159	207
14NiCrMo13-4	1.6657	255	241	187	241	166	217

1) see 7.2.2.3

Table 8 — Requirements for microscopic degree of purity when tested in accordance with DIN 50 602 (method K) (valid for oxidic non-metallic inclusions)

Bars Diameter <i>d</i> mm	Total characteristic value K (oxides) for the individual cast
$140 < d \leq 200$	$K 4 \leq 50$
$100 < d \leq 140$	$K 4 \leq 45$
$70 < d \leq 100$	$K 4 \leq 40$
$35 < d \leq 70$	$K 4 \leq 35$
$17 < d \leq 35$	$K 3 \leq 40$
$8 < d \leq 17$	$K 3 \leq 30$
$d \leq 8$	$K 2 \leq 35$

Table 9 — Requirements for microscopic degree of purity when tested in accordance with NF A 04-106

Inclusion type	Series	Limiting value
Type B	fine	$\leq 2,5$
	thick	≤ 1
Type C	fine	$\leq 0,5$
	thick	$\leq 0,5$
Type D	fine	$\leq 1,5$
	thick	$\leq 0,5$

Table 10 — Requirements for microscopic degree of purity when tested in accordance with SS 11 11 16

Inclusion type	Series	Limiting value
Type B	fine	≤ 4
	medium	≤ 3
	thick	≤ 2
Type C	fine	≤ 4
	medium	≤ 3
	thick	≤ 2
Type D	fine	≤ 4
	medium	≤ 2
	thick	≤ 1



Table 11 — Conditions for heat treating test bars and treatment of the steels¹⁾

Steel designation		End quench test	Carburizing temperature ³⁾	Core-hardening temperature ⁴⁾⁵⁾	Case-hardening temperature ⁴⁾⁵⁾	Tempering ⁶⁾
name	number	Quenching ²⁾	°C	°C	°C	°C
C10E	1.1121	—	880 to 980	880 to 920	780 to 820	150 to 200
C10R	1.1207					
C15E	1.1141	—	880 to 980	880 to 920	780 to 820	150 to 200
C15R	1.1140					
C16E	1.1148	—	880 to 980	880 to 920	780 to 820	150 to 200
C16R	1.1208					
17Cr3	1.7016	880	880 to 980	860 to 900	780 to 820	150 to 200
17CrS3	1.7014					
28Cr4	1.7030	850	880 to 980	860 to 900	780 to 820	150 to 200
28CrS4	1.7036					
16MnCr5	1.7131	870	880 to 980	860 to 900	780 to 820	150 to 200
16MnCrS5	1.7139					
16MnCrB5	1.7160	870	880 to 980	860 to 900	780 to 820	150 to 200
20MnCr5	1.7147	870	880 to 980	860 to 900	780 to 820	150 to 200
20MnCrS5	1.7149					
18CrMo4	1.7243	880	880 to 980	860 to 900	780 to 820	150 to 200
18CrMoS4	1.7244					
22CrMoS3-5	1.7333	900	880 to 980	860 to 900	780 to 820	150 to 200
20MoCr3	1.7320	880	880 to 980	860 to 900	780 to 820	150 to 200
20MoCrS3	1.7319					
20MoCr4	1.7321	910	880 to 980	860 to 900	780 to 820	150 to 200
20MoCrS4	1.7323					
16NiCr4	1.5714	880	880 to 980	850 to 890	780 to 820	150 to 200
16NiCrS4	1.5715					
10NiCr5-4	1.5805	880	875 to 925	830 to 860	780 to 810	150 to 200
18NiCr5-4	1.5810	880	880 to 980	840 to 880	780 to 820	150 to 200
17CrNi6-6	1.5918	870	880 to 980	830 to 870	780 to 820	150 to 200
15NiCr13	1.5752	880	880 to 980	840 to 880	780 to 820	150 to 200
20NiCrMo2-2	1.6523	920	880 to 980	860 to 900	780 to 820	150 to 200
20NiCrMoS2-2	1.6526					
17NiCrMo6-4	1.6566	880	880 to 980	830 to 870	780 to 820	150 to 200
17NiCrMoS6-4	1.6569					
20NiCrMoS6-4	1.6571	880	880 to 980	830 to 870	780 to 820	150 to 200
18CrNiMo7-6	1.6587	860	880 to 980	830 to 870	780 to 820	150 to 200
14NiCrMo13-4	1.6657	880	880 to 980	840 to 880	780 to 820	150 to 200

¹⁾ The temperatures given for carburizing, core-hardening, case-hardening and tempering are for guidance; the actual temperatures chosen should be those that will give the properties required.

²⁾ Time for austenitizing as a guide: 0,5 h minimum.

³⁾ The carburizing temperature will depend on the chemical composition of the steel, the mass of the product, and the carburizing medium. If the steels are direct hardened, in general, a temperature of 950 °C is not exceeded. For special procedures, for example under vacuum, higher temperatures (for example 1 020 to 1 050 °C) are not unusual.

⁴⁾ When applying the single quench method, the steel is to be quenched from the carburizing temperature or a lower temperature. The lower hardening temperatures are in each case to be preferred, in particular when there is risk of distortion.

⁵⁾ The kind of quenching agent depends on, for example, the shape of the products, the cooling conditions and the amount of furnace filling.

⁶⁾ Time for tempering as a guide: 1 h minimum.

Table 12 — Test conditions for the verification of the requirements given in column 2

NOTE Verification of the requirements is only necessary if an inspection certificate or an inspection report is ordered and if the requirement is applicable according to Table 1, column 9 or 10.

1	2	3	4	5	6	7	
No.	Requirements	Amount of testing			Sampling and sample preparation ²⁾	Test method to be used	
		see Table	Test unit ¹⁾	Number of			
			sample products per test unit	tests per sample product			
1	Chemical composition	3 + 4	C	(The cast analysis is given by the manufacturer; for product analysis see A.3).			
2	Hardenability	5 + 6	C	1	1	<p>In cases of dispute, the test piece shall be prepared as follows:</p> <p>a) For diameters ≤ 40 mm, the test piece shall be produced by machining.</p> <p>b) For diameters > 40 mm ≤ 150 mm, the bar shall be reduced by forging to a diameter of 40 mm.</p> <p>c) For diameters > 150 mm, the test piece shall be taken so that its axis is 20 mm below the surface.</p> <p>In all other cases, unless otherwise agreed at the time of ordering, the sampling method is left to the discretion of the manufacturer.</p> <p>If the product dimensions do not permit samples to be taken for the end quench hardenability test, conditions shall be agreed for proof of hardenability.</p>	<p>In accordance with EURONORM 23. The quenching temperature shall be as specified in Table 11. The hardness values shall be determined in accordance with method C in EN 10109-1.</p>



Table 12 — Test conditions for the verification of the requirements given in column 2

NOTE Verification of the requirements is only necessary if an inspection certificate or an inspection report is ordered and if the requirement is applicable according to Table 1, column 9 or 10.

1	2		3	4	5	6	7
No.	Requirements	see Table	Amount of testing		Number of	Sampling and sample preparation ²⁾	Test method to be used
			Test unit ¹⁾	sample products per test unit			
3	Hardness in the condition +S or +A or +TH or +FP	7	C+D +T	1	1	In cases of dispute, the hardness shall be determined, if possible at the following point on the surface: – in the case of round bars, a distance of 1 × the diameter from the end of the bar – in the case of bars with a rectangular or square cross section and, in the case of flat products, at a distance 1 × the thickness from the end and 0,25 × the thickness from one longitudinal edge on the transverse side of the product. If, for example, in the case of hammer or drop forgings, the above requirements cannot be adhered to, agreement shall be reached at the time of ordering about the most appropriate position for the hardness indentations. For sample preparation, see EN 10003-1.	In accordance with EN 10003-1.

¹⁾ The tests shall be carried out separately for each cast as indicated by "C", each dimension as indicated by "D", and each heat-treatment batch as indicated by "T".
 Products with different thickness may be grouped if the differences in thickness do not affect the properties.

²⁾ The general conditions for selection and preparation of samples and test pieces should be in accordance with EN ISO 377 and ISO 14284.

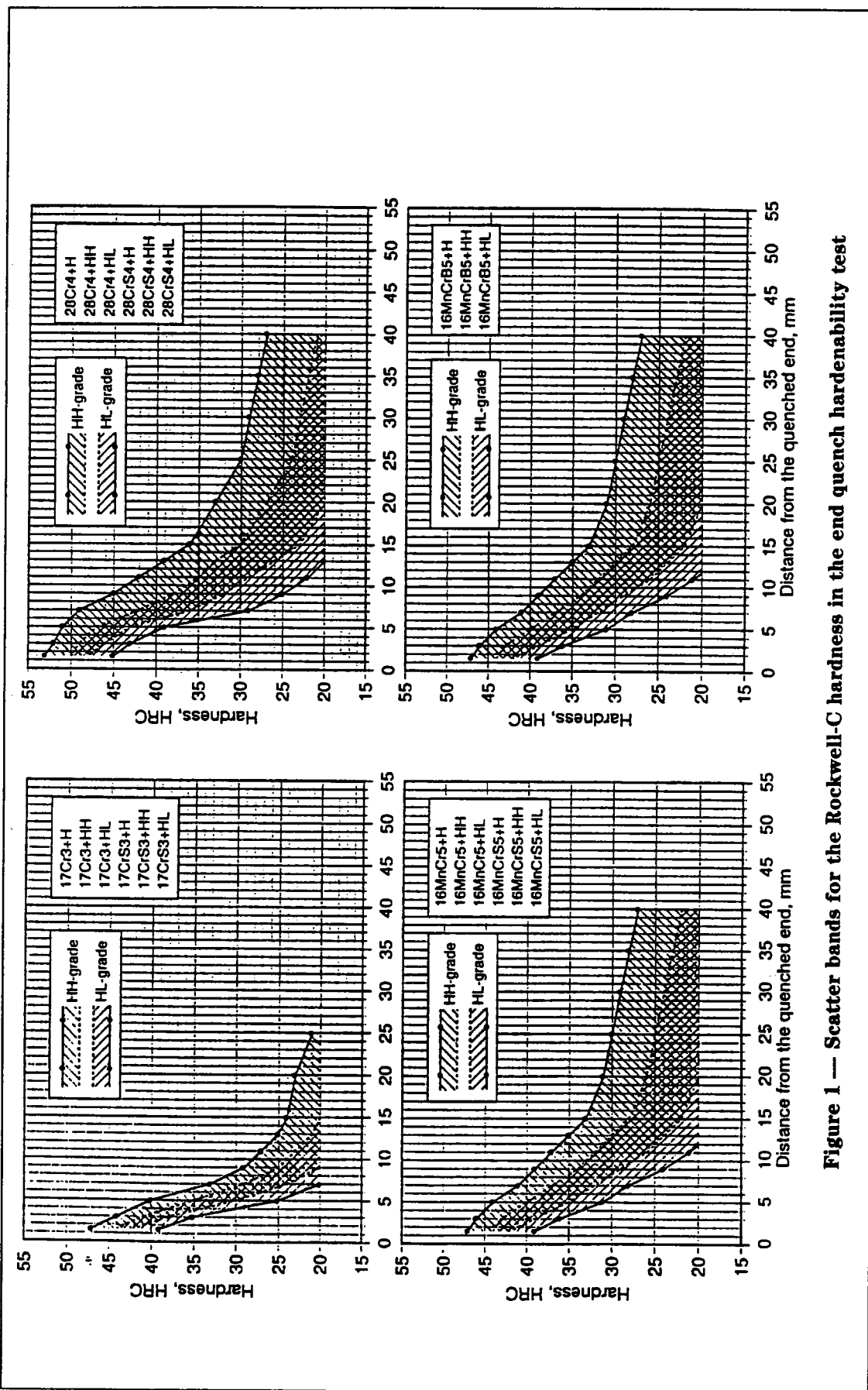


Figure 1 — Scatter bands for the Rockwell-C hardness in the end quench hardenability test

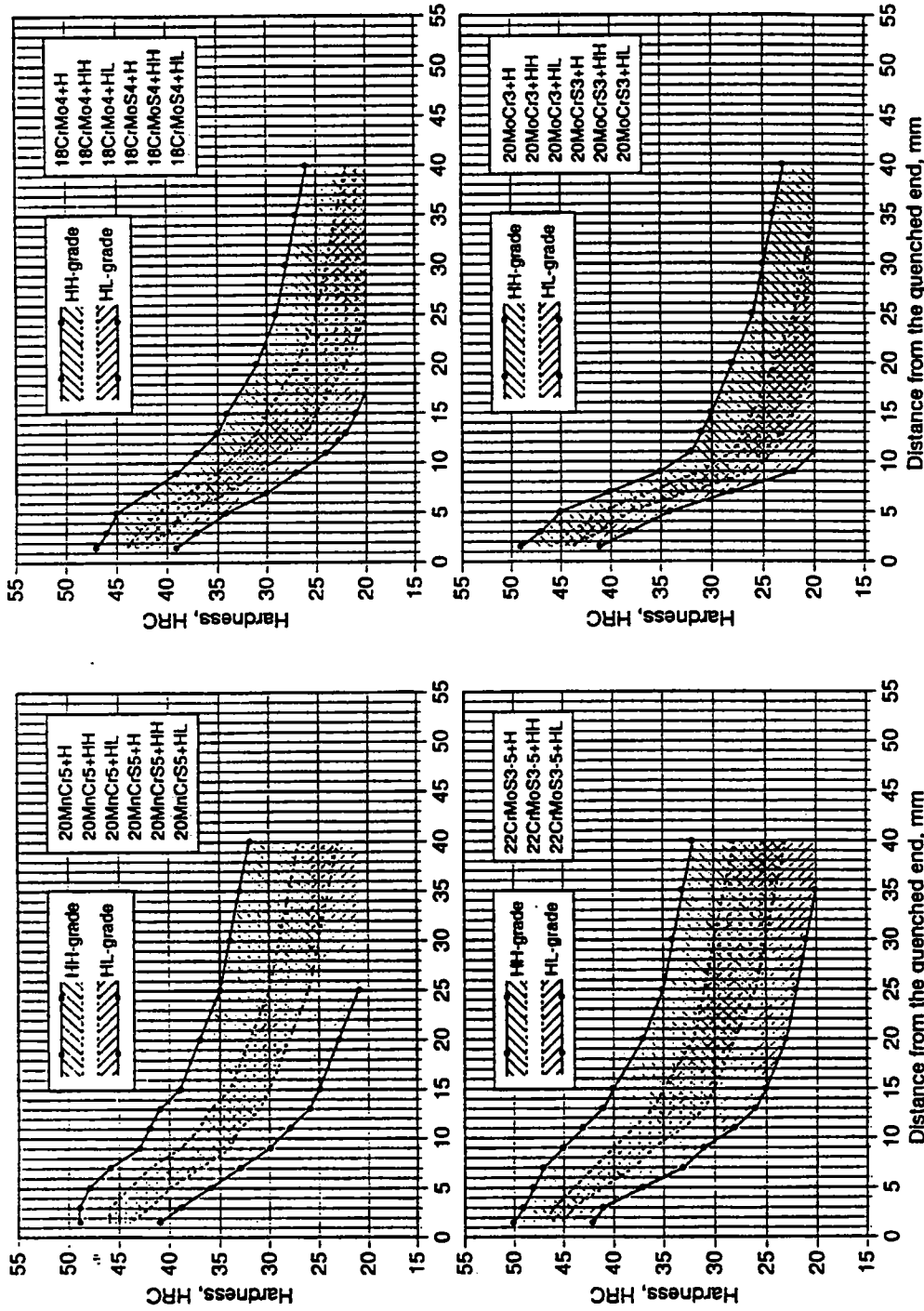


Figure 1 — Scatter bands for the Rockwell-C hardness in the end quench hardenability test (continued)

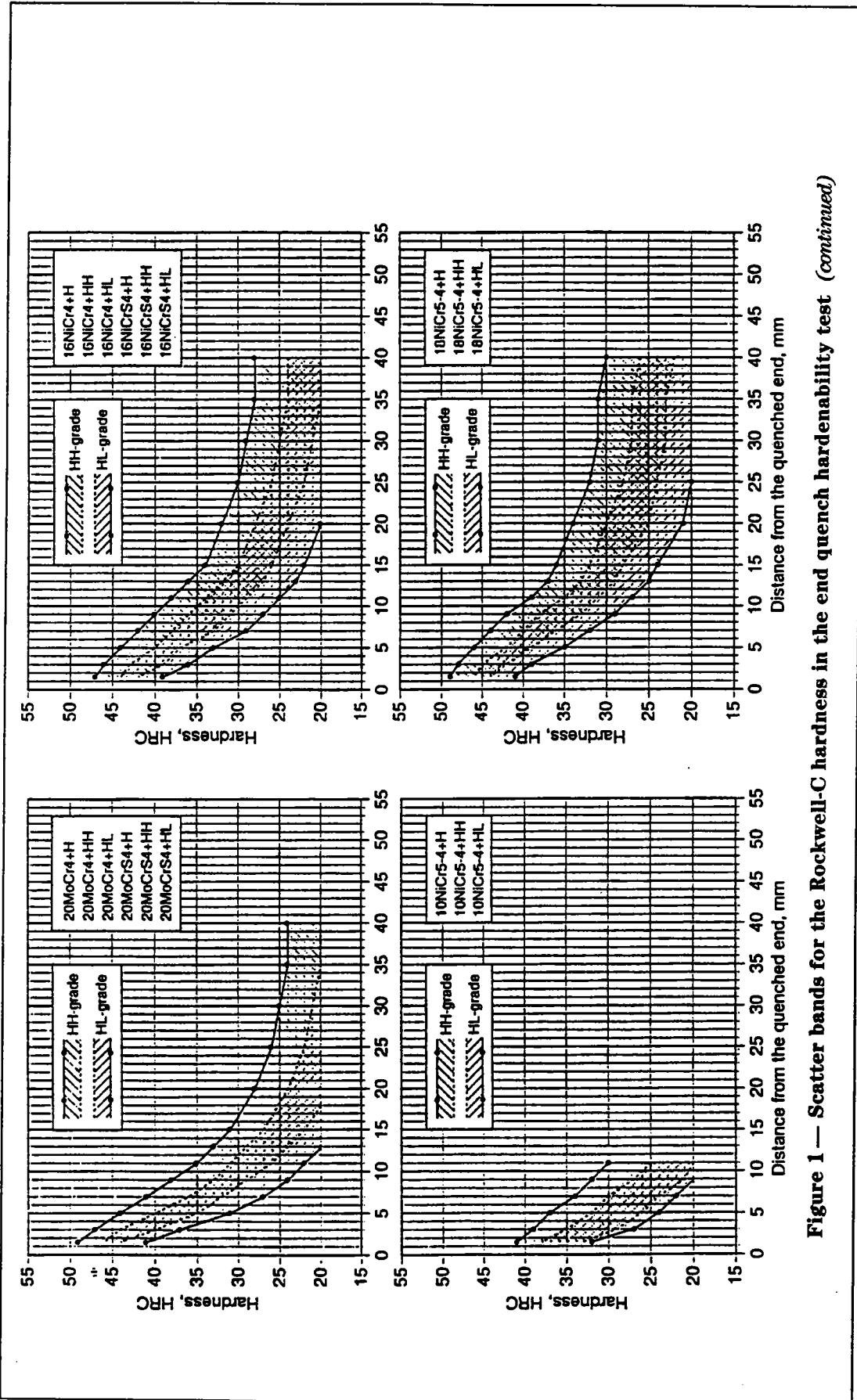


Figure 1 — Scatter bands for the Rockwell-C hardness in the end quench hardenability test (continued)

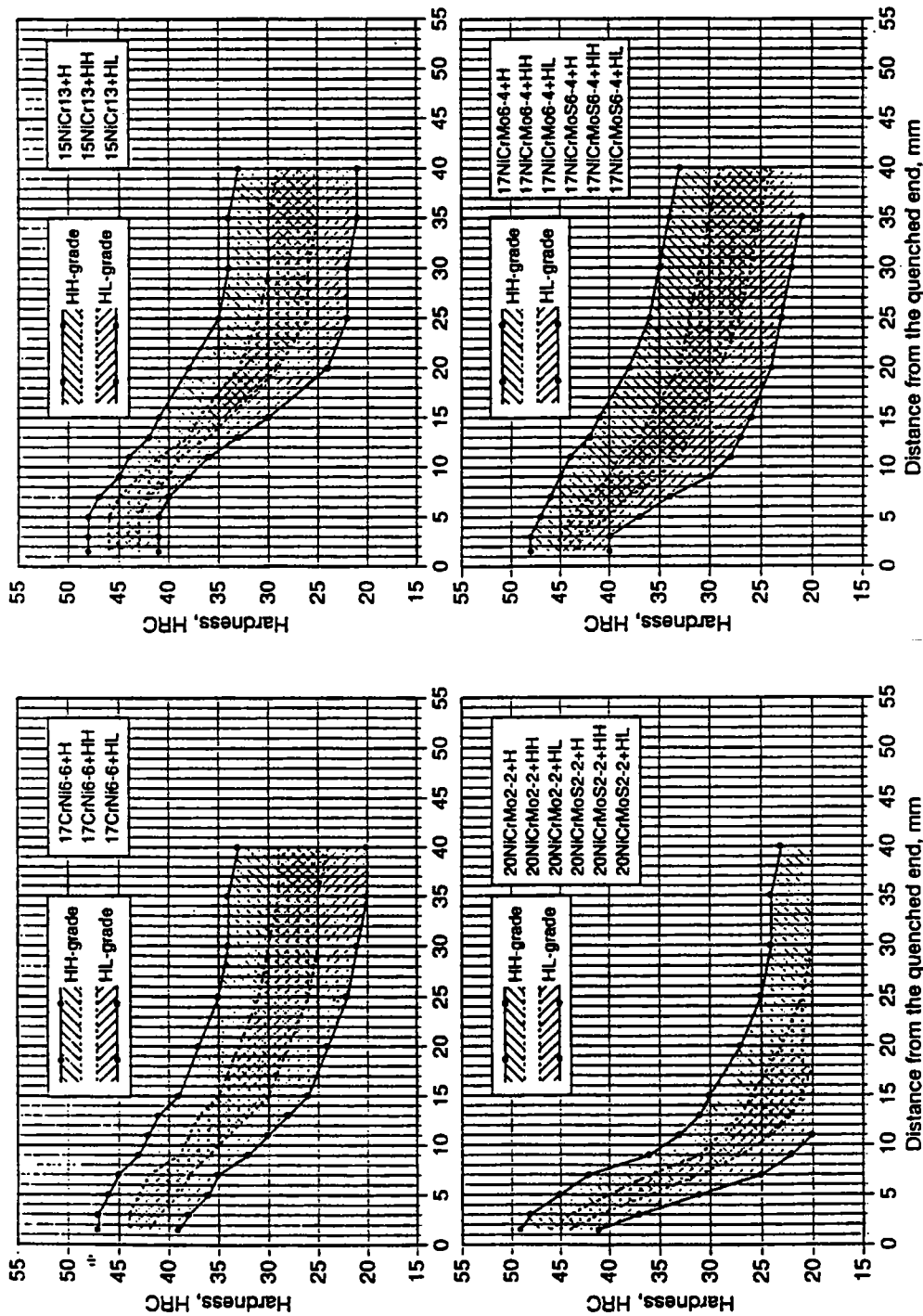


Figure 1 — Scatter bands for the Rockwell-C hardness in the end quench hardenability test (continued)

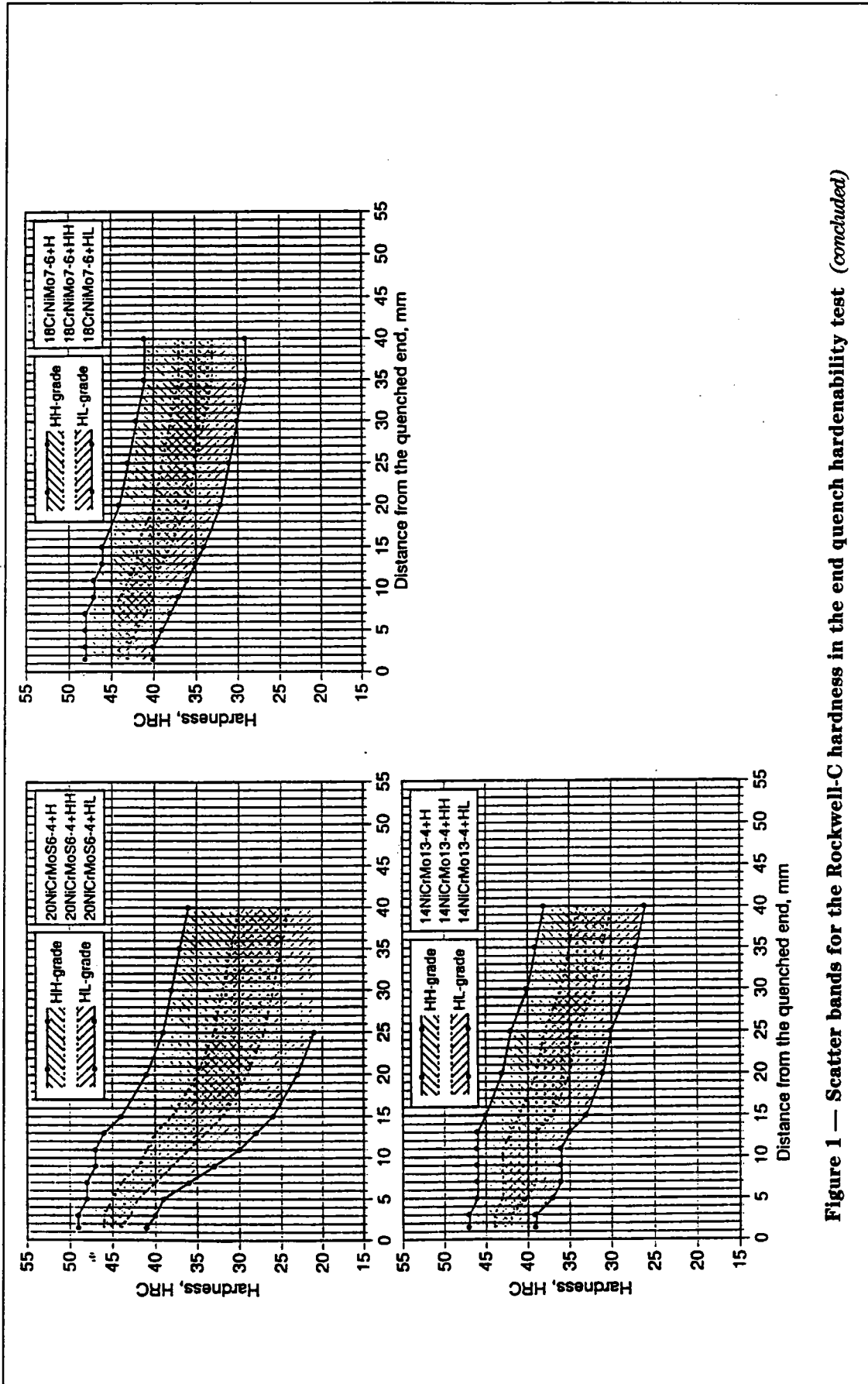


Figure 1 — Scatter bands for the Rockwell-C hardness in the end quench hardenability test (concluded)

Annex A (normative)

Supplementary or special requirements

NOTE One or more of the following supplementary or special requirements may be agreed upon at the time of enquiry and order. The details of these requirements may be agreed upon between the manufacturer and the purchaser at the time of enquiry and order if necessary.

A.1 Non-metallic inclusion content

The microscopically determined non-metallic inclusion content shall be within agreed limits when tested according to a procedure to be agreed at the time of enquiry and order (see annex D).

The requirements for non-metallic inclusion content apply in every case. However, proof requires a special agreement.

A.2 Non-destructive testing

The products shall be non-destructively tested in accordance with a method to be agreed upon at the time of enquiry and order and to acceptance criteria also to be agreed upon at the time of enquiry and order.

A.3 Product analysis

One product analysis shall be carried out per cast for the determination of elements for which values are specified for the cast analysis (see Table 3) of the steel grade concerned.

Sampling shall be carried out as specified in ISO 14284. In cases of dispute, the method used shall be agreed if possible with reference to the corresponding European Standards or Euronorms.

A.4 Reduction ratio

Where central soundness in the end product is important, the purchaser must be aware that a reduction ratio of 4:1 (based on cross-sectional area) is necessary. For hot-rolled and forged products, a minimum reduction ratio can be agreed at the time of enquiry and order (see 6.3).

A.5 Special marking

The product shall be marked in a way specially agreed at the time of enquiry and order.

Annex B (informative)

Bibliography

Euronorms and European Standards for similar steel grades as in Table 3, which are intended for other product forms, treatment conditions or special applications are:

- EN 10083-1, *Quenched and tempered steels — Part 1: Technical delivery conditions for special steels.*
- EN 10083-2, *Quenched and tempered steels — Part 2: Technical delivery conditions for unalloyed quality steels.*

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

EN 10087, *Free-cutting steels — Technical delivery conditions.*

prEN 10263-1, *Steel rod, bars and wire for cold heading and cold extrusion — Part 1: General technical delivery conditions.*

prEN 10263-3, *Steel rod, bars and wire for cold heading and cold extrusion — Part 3: Technical delivery conditions for case hardening steels.*

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

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

EURONORM 85, *Nitriding steels; quality specifications.*

EURONORM 86, *Steels for flame and induction hardening; quality specifications.*

EURONORM 89, *Alloy steels for hot-formed and heat-treated springs; quality specifications.*

Annex C (informative)

Dimensional standards applicable to products complying with this European Standard

For hot rolled rod:

EURONORM 17, *Rod in general purpose non-alloy steel for cold drawing; dimensions and tolerances.*

EURONORM 108, *Round steel rod for cold-stamped bolts and nuts; dimensions and tolerances.*

For hot rolled bars:

EURONORM 58, *Hot rolled flats for general purposes.*

EURONORM 59, *Hot rolled square bars for general purposes.*

EURONORM 60, *Hot rolled round bars for general purposes.*

EURONORM 61, *Hot rolled steel hexagons.*

EURONORM 65, *Hot rolled round steel bars for screws and rivets.*

For hot rolled sheet, strip and plate:

EN 10029, *Hot rolled steel plates 3 mm thick or above; tolerances on dimensions, shape and mass.*

EN 10048, *Hot rolled narrow steel strip; tolerances on dimensions and shape.*

EN 10051, *Continuously hot rolled uncoated plate, sheet and strip of non-alloy and alloy steels; tolerances on dimensions and shape.*

EURONORM 91, *Hot rolled wide flats; tolerances on dimensions, shape and mass.*

Annex D (normative)

Determining the non-metallic inclusion content

D.1 At the time of publication of this European Standard, no standardized test method exists in Europe for the microscopic determination of non-metallic inclusions in special steels. However, several national test methods have been standardized. Until the European Standard is published, agreement may be reached at the time of enquiry and order on a test in accordance with DIN 50602 or NF A 04-106 or SS 111116.

NOTE ISO 4967:1979, *Steel — Determination of content of non-metallic inclusions — Micrographic method using standard diagrams* is identical to NF A 04-106.

D.2 The following requirements are applicable.

D.2.1 If evidence is provided in accordance with DIN 50602, the requirements specified in Table 8 apply.

D.2.2 If evidence is provided in accordance with NF A 04-106, the requirements specified in Table 9 apply.

D.2.3 If evidence is provided in accordance with SS 111116, the requirements specified in Table 10 apply.

Annex E (Informative)

Comparison of steel grades specified in this European Standard and ISO 683-11:1987 and other steel grades previously standardized nationally

prEN 10084		ISO 683-11: 1987	Germany		Finland	France	Italy	Spain	Sweden	United Kingdom
name	number		name	number						
C10E	1.1121	C10	Ck10	1.1121		XC10	C10	C10k		045M10
C10R	1.1207									
C15E	1.1141	C15E4	Ck15	1.1141	505		C15	C16k		
C15R	1.1140	C15M2	Cm15	1.1140				C16k-1	SS1370	
C16E	1.1148	C16E4	—	—		XC 18		—		080M15
C16R	1.1208									
17Cr3	1.7016	—	17Cr3	1.7016				—		527M17
17CrS3	1.7014	—	—	—				—		
28Cr4	1.7030	—	28Cr4	1.7030				—		
28CrS4	1.7036	—	28CrS4	1.7036						
16MnCr5	1.7131	16MnCr5	16MnCr5	1.7131		16MC5	16MnCr5	16MnCr5		590M17
16MnCrS5	1.7139	16MnCrS5	16MnCrS5	1.7139				16MnCr5-1	SS2127	
16MnCrB5	1.7160	—	—	—				—		
20MnCr5	1.7147	20MnCr5	20MnCr5	1.7147	510	20MC5	20MnCr5	—		
20MnCrS5	1.7149	20MnCrS5	20MnCrS5	1.7149				—		
18CrMo4	1.7243	18CrMo4	—	—		18CD4	18CrMo4	18CrMo4		708M20
18CrMoS4	1.7244	18CrMoS4	—	—				18CrMo4-1		
22CrMoS3-5	1.7333	—	22CrMoS-3-5	1.7333				—		
20MoCr3	1.7319	—	—	—				—		
20MoCr4	1.7321	—	20MoCr4	1.7321				20MoCr5		
20MoCrS4	1.7323	—	20MoCrS4	1.7323				20MoCr5-1		
16NiCr4	1.5714	—	—	—			16CrNi4	—		637M17
16NiCrS4	1.5715	—	—	—			16CrNiS4	—	SS2511	
10NiCr5-4	1.5805					10NC6		—		
18NiCr5-4	1.5810	—	—	—		20NC6		—		
17CrNi6-6	1.5918	—	—	—				—		
15NiCr13	1.5752	15NiCr13	—	—				—		(655M13)
20NiCrMo2-2	1.6523	20NiCrMo2	21NiCrMo2	1.6523	506	20NCD2	20NiCrMo2	20NiCrMo2		805M20
20NiCrMoS2-2	1.6526	20NiCrMoS2	21NiCrMoS-2	1.6526			20NiCrMoS2	20NiCrMo2-1	SS2506	
17NiCrMo6-4	1.6566	17NiCrMo6	—	—		18NCD6	18NiCrMo5	—	SS2523	815M17
17NiCrMoS6-4	1.6569	—	—	—			18NiCrMoS5	—		
20NiCrMoS6-4	1.6571	—	—	—				—		
18CrNiMo7-6	1.6587	18CrNiMo7	17CrNiMo6	1.6587	511		16NiCrMo12	—		
14NiCrMo13-4	1.6657						16NiCrMo12			

Annex F (informative)
Classification of steel grades according to minimum tensile strength as a function of diameter after quenching and tempering at 200 °C

$R_{m, \min}$ (N/mm ²)			
1200	20MnCr5, 20MnCrS5, 17NiCrMo6-4, 17NiCrMoS6-4, 20NiCrMoS6-4		
1100	18NiCr5-4, 17CrNi6-6, 18CrNiMo7-6, 14NiCrMo13-4	18NiCr5-4, 17CrNi6-6, 18CrNiMo7-6 20NiCrMoS6-4 14NiCrMo13-4	
1000	22CrMoS3-5 18CrMo4, 18CrMoS4, 20NiCrMo2-2, 20NiCrMoS2-2 15NiCr13 16MnCr5, 16MnCrS5, 16MnCrB5	17NiCrMo6-4, 17NiCrMoS6-4 20MnCr5, 20MnCrS5 22CrMoS3-5	
900	16NiCr4, 16NiCrS4 20MoCr3, 20MoCrS3, 20MoCr4, 20MoCrS4 28Cr4, 28CrS4, 10NiCr5-4	18CrMo4, 18CrMoS4, 15NiCr13 16MnCr5, 16MnCrS5, 16MnCrB5, 16NiCr4, 16NiCrS4 20NiCrMo2-2, 20NiCrMoS2-2 20MoCr3, 20MoCrS3, 20MoCr4, 20MoCrS4	18NiCr5-4, 17CrNi6-6, 18CrNiMo7-6 14NiCrMo13-4 22CrMoS3-5, 17NiCrMo6-4, 17NiCrMoS6-4, 20NiCrMoS6-4
800	C16E, C16R, 17Cr3, 17CrS3		15NiCr13 20MnCr5, 20MnCrS5
700	C15E, C15R	28Cr4, 28CrS4, 10NiCr5-4 17Cr3, 17CrS3	
600		C16E, C16R C15E, C15R	18CrMo4, 18CrMoS4, 20NiCrMo2-2, 20NiCrMoS2-2, 28Cr4, 16MnCr5, 16MnCrS5, 16MnCrB5
500	C10E, C10R	C10E, C10R	10NiCr5-4
400	$d \leq 16$ mm	16 mm < $d \leq 40$ mm	40 mm < $d \leq 100$ mm



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National annex NA (informative)**Non-conflicting national additions**

In the United Kingdom the steels in this annex are widely used but they have not been included in the European Standard. This annex gives chemical composition, mechanical property and hardenability requirements for the steels. All other requirements of EN 10084 shall apply.

Table NA.1 — Chemical composition

Steel	C	Si	Mn	P max.	S max.	Cr	Mo	Ni
665H17	0,14 to 0,20	0,10 to 0,35	0,35 to 0,75	0,035	0,035	—	0,20 to 0,30	1,50 to 2,00
665M17	0,14 to 0,20	0,10 to 0,35	0,35 to 0,75	0,035	0,035	—	0,20 to 0,30	1,50 to 2,00

Table NA.2 — Hardness limits for steel types with specified (normal) hardenability (H-grades)

Steel	Limits of range	Hardness HRC at a distance from quenched end of test piece mm															
		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50	
665H17	max.	46	44	41	36	31	28	25	24	22	21	20					
	min.	39	33	24	21												

Table NA.3 — Heat treatment requirements and mechanical properties

Steel	End quench test Quenching temperature °C	Carburizing temperature °C	Test bar diameter mm	Tensile strength R_m N/mm ² min.	A % min.	Impact KV J min.
665M17	—	880 to 930	19	770	12	35

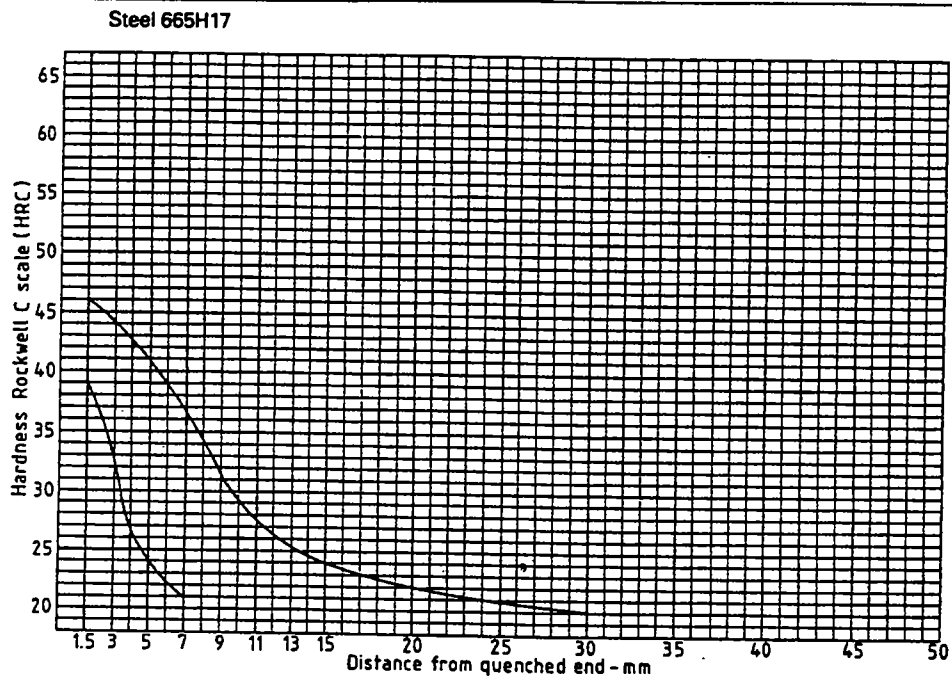


Figure NA.1