

Case hardening steels — Technical delivery conditions

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National foreword

This British Standard is the UK implementation of EN 10084:2008. It supersedes BS EN 10084:1998 which is withdrawn.

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

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Foreword

This document (EN 10084:2008) has been prepared by Technical Committee ECISS/TC 23 "Steels for heat treatment, alloy steels and free-cutting steels - Qualities and dimensions", 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of an identical text or by endorsement, at the latest by October 2008, and conflicting national standards shall be withdrawn at the latest by October 2008.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 10084:1998.

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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 NOTE 2 and NOTE 3),
- bars (see NOTE 2),
- rod,
- wide flats, quarto plates,
- hot-rolled sheet/plate and strip,
- hammer and drop forgings (see NOTE 2),

manufactured from the case hardening non alloyed 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 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 European Standards for similar steel grades are listed in the Bibliography.

NOTE 2 Hammer-forged semi-finished products (blooms, billets, slabs, etc.), seamless rolled rings 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 non-deformed 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

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

EN 10021, *General technical delivery conditions for steel products*

EN 10027-1, *Designation systems for steels - Part 1: Steel names*

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 10160, *Ultrasonic testing of steel flat product of thickness equal to or greater than 6 mm (reflection method)*

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*

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

EN 10247:2007, *Micrographic examination of the non-metallic inclusion content of steels using standard pictures*

prCEN/TR 10261, *Iron and steel - Review of available methods of chemical analysis*

EN 10308, *Non destructive testing – Ultrasonic testing of steel bars*

EN ISO 377, *Steel and steel products - Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997)*

EN ISO 642, *Steel - Hardenability test by end quenching (Jominy test) (ISO 642:1999)*

EN ISO 643, *Steels – Micrographic determination of the apparent grain size (ISO 643:2003)*

EN ISO 6506-1, *Metallic materials - Brinell hardness test - Part 1: Test method (ISO 6506-1:2005)*

EN ISO 6508-1, *Metallic materials - Rockwell hardness test - Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T) (ISO 6508-1:2005)*

EN ISO 14284, *Steel and iron - Sampling and preparation of samples for the determination of chemical composition (ISO 14284:1996)*

3 Terms and definitions

For the purposes of this European Standard the terms and definitions given in EN 10020, EN 10021, EN 10052, EN 10079, EN ISO 377 and EN ISO 14284 and the following apply.

3.1

case-hardening steels

steels with a relatively low carbon content which are intended for carburising or carbonitriding and subsequent hardening

NOTE Such steels, after treatment, are characterised by a high hardness surface layer and a tough core.

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 Table 3, Table 5 and Table 6 are allocated in accordance with EN 10027-1.

4.2.2 Steel numbers

For the steel grades covered by this European Standard, the steel numbers as given in Table 3, Table 5 and Table 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) quantity to be delivered;
- b) designation of the product form (e.g. round bar or square bar);
- c) number of the dimensional standard (see 7.6 and Annex B);
- d) dimensions and tolerances on dimensions and shape and, if applicable, letters denoting relevant special tolerances;
- e) number of this European Standard (EN 10084);
- f) steel name or steel number (see 4.2);
- g) 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).

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) any:

- a) particular heat-treatment condition at delivery (see 6.4.2 and Table 1);
- b) particular surface condition at delivery (see 6.4.3 and Table 2);
- c) requirement concerning minimum reduction ratio or minimum thickness deformation ratio of rolled and forged products (see 6.3 and A.5);
- d) verification of fine grain size (see 7.3.1, 8.2.3 and A.4);
- e) requirement for the verification of non-metallic inclusion content (see 7.3.2, A.1 and Annex C);
- f) requirement for restricted hardenability scatter bands for alloy steels (+HH, +HL-grades, see 7.1.2 and Table 6);
- g) verification of hardenability and if agreed the information about calculation of the hardenability (see 8.2.2);

- h) requirement for internal soundness (see 7.4 and A.2);
- i) requirement relating to surface quality (see 7.5.3);
- j) requirement concerning suitability of bars and rod for bright drawing (see 7.5.4);
- k) requirement relating to removal of surface defects (see 7.5.5);
- l) requirement concerning special marking of the products (see clause 9 and A.6);
- m) verification of the product analysis (see A.3).

EXAMPLE

20 round bars with nominal diameter 40 mm and the nominal length of 8 000 mm according to EN 10060 made of steel grade 20MnCr5 (1.7147) according to EN 10084 in the heat treatment condition +A with surface condition +BC, test report 2.2 as specified in EN 10204

20 round bars EN 10060 - 40x8000
EN 10084 - 20MnCr5+A+BC
EN 10204 -2.2

or

20 round bars EN 10060 - 40x8000
EN 10084 - 1.7147+A+BC
EN 10204 - 2.2

6 Manufacturing process

6.1 Melting process

The type of melting process shall be 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 or minimum thickness deformation ratio of rolled and forged products see A.5.

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, line 3 to line 8.

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 Table 2, line 3 to line 7.

6.5 Cast separation

The products shall be delivered as 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 Table 3 to Table 7 (chemical composition, hardenability, maximum hardness, hardness range).

7.1.2 Unless otherwise agreed for alloy steels the hardenability requirements given in Table 5 apply. If agreed at the time of enquiry and order alloy steels with restricted hardenability scatter bands given in Table 6 shall be supplied.

7.2 Technological properties

7.2.1 Machinability

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

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

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 "soft annealed".

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, 18CrNiMo7-6, 14NiCrMo13-4 and 20NiCrMo13-4 and the corresponding grades with requirements on hardenability (see Table 5 and Table 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 non alloyed 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 Table 5 and Table 6) are shearable in the untreated condition under suitable conditions.

7.3 Structure

7.3.1 Grain size

Unless otherwise agreed the steel shall show a fine grain structure with an austenitic grain size of 5 or finer (see 8.2.3 and A.4).

7.3.2 Non-metallic inclusions

7.3.2.1 Microscopic inclusions

The steels shall have a degree of cleanliness corresponding to the special steel quality (see A.1.1 and Annex C).

7.3.2.2 Macroscopic inclusions

As freedom from macroscopic inclusions cannot be ensured in any steel, requirements to verify the level present may be agreed at the time of enquiry and order (see Annex A.1.2).

7.4 Internal soundness

Where appropriate, requirements relating to the internal soundness of products shall be agreed at the time of enquiry and order, if possible with reference to European standards. EN 10160 specifies requirements of ultrasonic testing of flat products of thickness equal to or greater than 6 mm and EN 10308 specifies requirements of ultrasonic testing of steel bars (see A.2).

7.5 Surface condition

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

7.5.2 Minor surface imperfections which can 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 plate/sheet 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 purchaser or his representative.

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

7.6 Dimensions, tolerances on dimensions and shape

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

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 2.2 is to be issued, it shall contain the following information:

- a) confirmation that the material complies with the requirements of the order;
- b) 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, inspection certificate 3.1 or 3.2 is to be issued, the specific tests described in 8.2 shall be carried out and the results shall be confirmed in the inspection certificate.

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

- a) the confirmation that the material complies with the requirements of the order;
- b) manufacturer's results for the cast analysis of all elements specified in Table 3 for the steel grade concerned, see Table 9;
- c) results of inspections and tests ordered as a result of supplementary options (see Annex A);
- d) symbol letters or numbers relating the inspection certificates, test pieces and products to each other.

8.2 Specific inspection and testing

8.2.1 Verification of hardness

For non alloy steels, the hardness requirements given in Table 1, column 8, sub-clause 2, shall be verified (see also Table 7 and Table 9).

8.2.2 Verification of hardenability

For alloy steels as far as available the manufacturer has the option to verify the hardenability by calculation. The calculation method is left to the discretion of the manufacturer. If agreed at the time of enquiry and order the manufacturer shall give sufficient information about the calculation for the customer to confirm the result.

If for certain steel grades a calculation formula is not available or in the case of dispute an end quench hardenability test shall be carried out in accordance with EN ISO 642 and Table 9. The temperature for quenching shall comply with Table 8 of this document. The hardness values shall be determined in accordance with EN ISO 6508-1, method C.

8.2.3 Verification of austenitic grain size

If the verification of fine grain structure is agreed at the time of enquiry and order, the verification of the austenitic fine grain size shall be made according to A.4.

8.2.4 Visual and dimensional inspection

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

8.2.5 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.6).

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

	1	2	3	4	5	6	7	8		9			10
1	Heat-treatment condition at delivery	Symbol	x = Applicable for					Applicable requirements for					Remarks
			Semi-finished products	Bars	Rod	Flat products	Hammer and drop forgings	Non alloy steel grades		Alloy steel grades			
								1.	2.	1.	2.	3.	
2	Untreated	None or + U	x	x	x	x	x	Chemical composition according to Tables 3 and 4	-	As in column 8 (see footnote b to Table 3)	Hardenability values according to Table 5 or Table 6	Observe also options given in Annex A.	
3	Treated to improve shearability	+ S	x	x	-	-	-		Column + S				
4	Soft annealed	+ A	x	x	x	x	x		Column + A				
5	Treated to hardness range	+ TH	-	x	x	x	x		Column + TH				
6	Treated to ferrite-pearlite structure and hardness range	+ FP	-	x	-	-	x		Column + FP				
7	Normalized ^a	+N	-	-	-	x	-		Column + N				
8	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 for spheroidal carbides (+AC)", as required for cold heading and cold extrusion, is covered by EN 10263-4.											
^a Normalizing may be replaced by normalizing forming.													

Table 2 — Surface condition at delivery

	1	2	3	4	5	6	7	8	9
1	Surface condition at delivery		Symbol	X = in general applicable for				hammer and drop forgings (see 1.1, Note 2)	Notes
				Semi-finished products such as blooms, billets	bars	rods	flat products		
2	Unless otherwise agreed	Hot worked	None or + HW	x	x	x	x	x	-
3	Particular conditions supplied by agreement	Unformed continuously cast	+CC	x	-	-	-	-	-
4		Hot worked and pickled	+ PI	-	-	x	x	-	a
5		Hot worked and blast cleaned	+ BC	x	x	x	x	x	a
6		Hot worked and rough machined	+ RM	-	x	x	-	x	a
7		Others	-	-	-	x	x	x	x
^a In addition certain surface treatments like oiled or limed or phosphated may be agreed.									

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

Steel grade		% by mass ^{a, b, c}								
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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 0,035	0,80 to 1,10	-	-	0,0008 to 0,0050 ^d
20MnCr5	1.7147	0,17 to 0,22	0,40	1,10 to 1,40	0,025	≤ 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	0,025	≤ 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	0,025	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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	≤ 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	0,025	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	0,025	≤ 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	0,025	≤ 0,035	0,80 to 1,10	0,20 to 0,30	3,00 to 3,50	-
20NiCrMo13-4	1.6660	0,17 to 0,22	0,40	0,30 to 0,60	0,025	≤ 0,035	0,80 to 1,20	0,30 to 0,50	3,00 to 3,50	-

- ^a 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 shall be taken to prevent the addition of such elements from scrap or other material used in manufacture which affect the hardenability, mechanical properties and applicability.
- ^b Where requirements are made on hardenability (see Table 5 and Table 6), slight deviations from the limits for the cast analysis are permitted, except for phosphorus and sulphur; these deviations shall, however, not exceed in the case of carbon $\pm 0,01$ % and in all other cases the values acc. to table 4.
- ^c Steels with improved machinability as a result of the addition of higher sulphur contents up to around 0,10 % S (including resulphurized steels with controlled inclusion content (e.g. Ca-treatment)) (modern method) or lead may be supplied on request. In the first case the upper limit for the manganese content may be increased by 0,15 %.
- ^d 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 ^a % 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 ^b
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
^a ± means that in one cast the deviation can occur over the upper value or under the lower value of the specified range in Table 3, but not both at the same time.		
^b For steels with a specified sulphur 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 grade		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
20NiCrMo13-4+H	1.6660+H	max.	53	52	52	51	51	51	51	51	51	50	50	50	49
		min.	43	42	42	41	41	41	41	41	41	40	40	40	39

Table 6 — Hardness limits for steel types with restricted hardenability scatterbands (+HH- and +HL-grades, see 7.1)

Steel grade		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

Table 6 (continued)

Steel grade		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
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	-	-	-	-
10 NiCr5-4+HH	1.505+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
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
		min.	44	41	36	31	27	24	22	21	-	-	-	-	-
20NiCrMoS2-2+HL	1.6526+HL	max.	46	44	40	36	31	29	27	26	23	21	20	20	-
		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
		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
		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
20NiCrMo13-4+HH	1.6660+HH	max.	53	52	52	51	51	51	51	51	51	50	50	50	49
		min.	44	44	44	43	43	43	43	43	43	42	42	42	41
20NiCrMo13-4+HL	1.6660+HL	max.	50	50	50	49	49	49	49	49	49	48	48	48	47
		min.	43	42	42	41	41	41	41	41	41	40	40	40	39

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

Steel grade		Brinell hardness (HBW) in the condition							
Name	Number	+ S max.	+ A max.	+ TH		+ FP		+N	
				min.	max.	min.	max.	min.	max.
C10E	1.1121	-	131	-	-	-	-	85	140
C10R	1.1207								
C15E	1.1141	-	143	-	-	-	-	95	150
C15R	1.1140								
C16E	1.1148	-	156	-	-	-	-	100	155
C16R	1.1208								
17Cr3	1.7016	a	174	-	-	-	-	-	-
17CrS3	1.7014								
28Cr4	1.7030	255	217	166	217	156	207	-	-
28CrS4	1.7036								
16MnCr5	1.7131	a	207	156	207	140	187	138	187
16MnCrS5	1.7139								
16MnCrB5	1.7160	a	207	156	207	140	187	138	187
20MnCr5	1.7147	255	217	170	217	152	201	140	201
20MnCrS5	1.7149								
18CrMo4	1.7243	a	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	a	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	a	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	-	-
20NiCrMo13-4	1.6660	277	255	207	255	197	241	-	-

^a See 7.2.2.3[°].

Table 8 — Conditions for heat treating test bars and treatment of the steels

Steel grade		End quench test Austenitizing temperature ^a °C	Carburizing temperature ^b °C	Core-hardening temperature ^{c,d} °C	Case-hardening temperature ^{c,d} °C	Tempering ^e °C
Name	Number					
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
20NiCrMo13-4	1.6660	850	880 to 980	825 to 880	800 to 850	150 to 200

NOTE 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.

a Time for austenitizing as a guide: 30 to 35 minutes.

b 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 °C to 1 050 °C) are not unusual.

c 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.

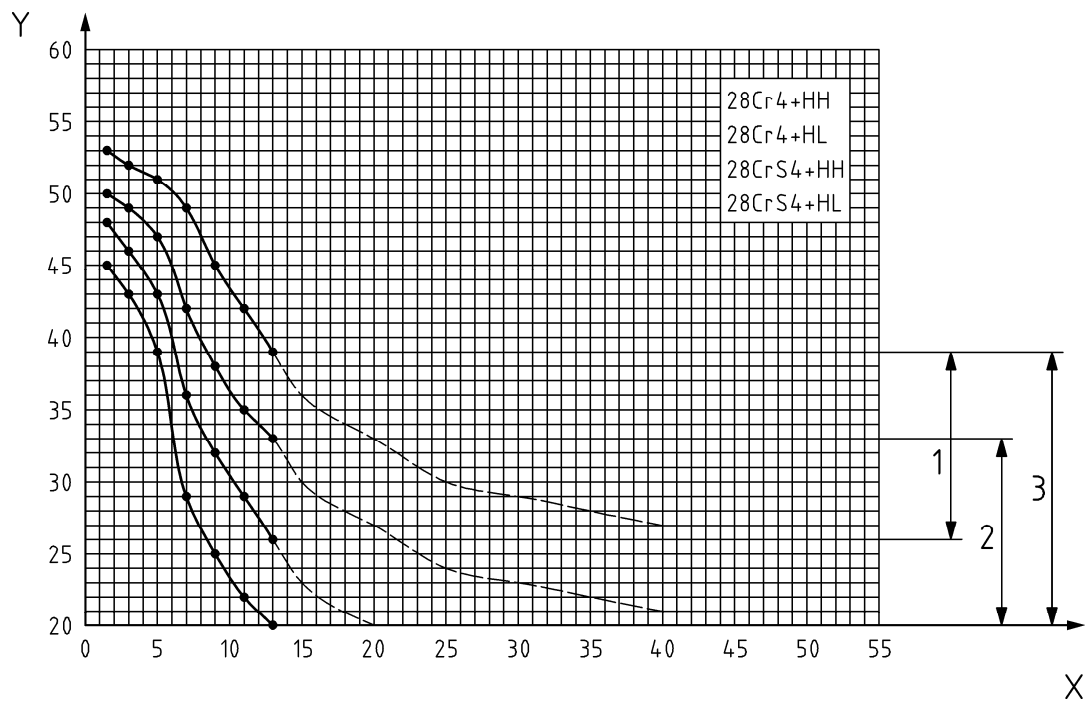
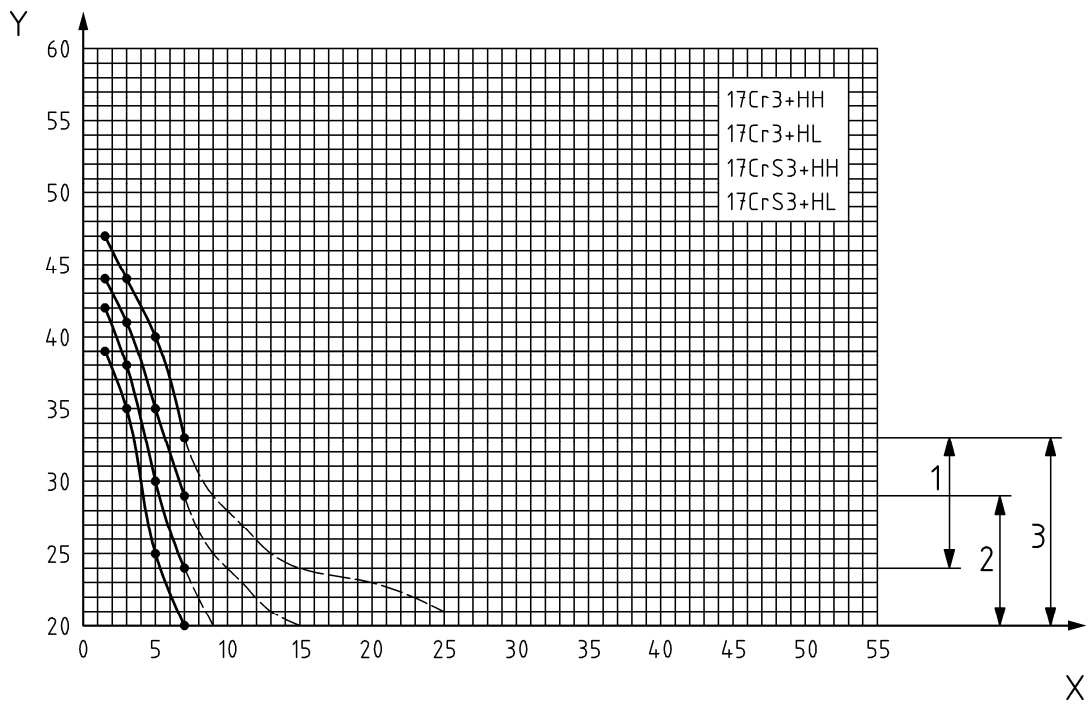
d The kind of quenching agent depends on, for example, the shape of the products, the cooling conditions and the amount of furnace filling.

e Time for tempering as a guide: 1 h minimum.

Table 9 — Test conditions for the verification of the requirements given in column 1

NOTE Verification of the requirements is only necessary if an inspection certificate is ordered and if the requirement is applicable according to Table 1, column 8 or column 9.

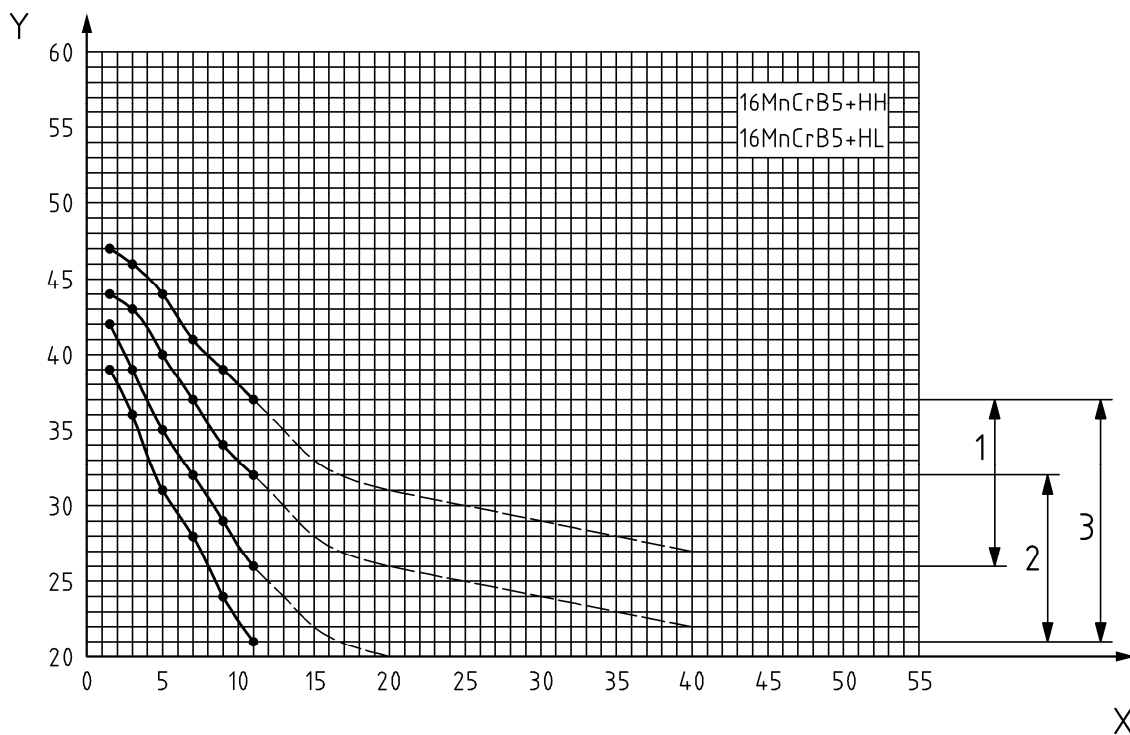
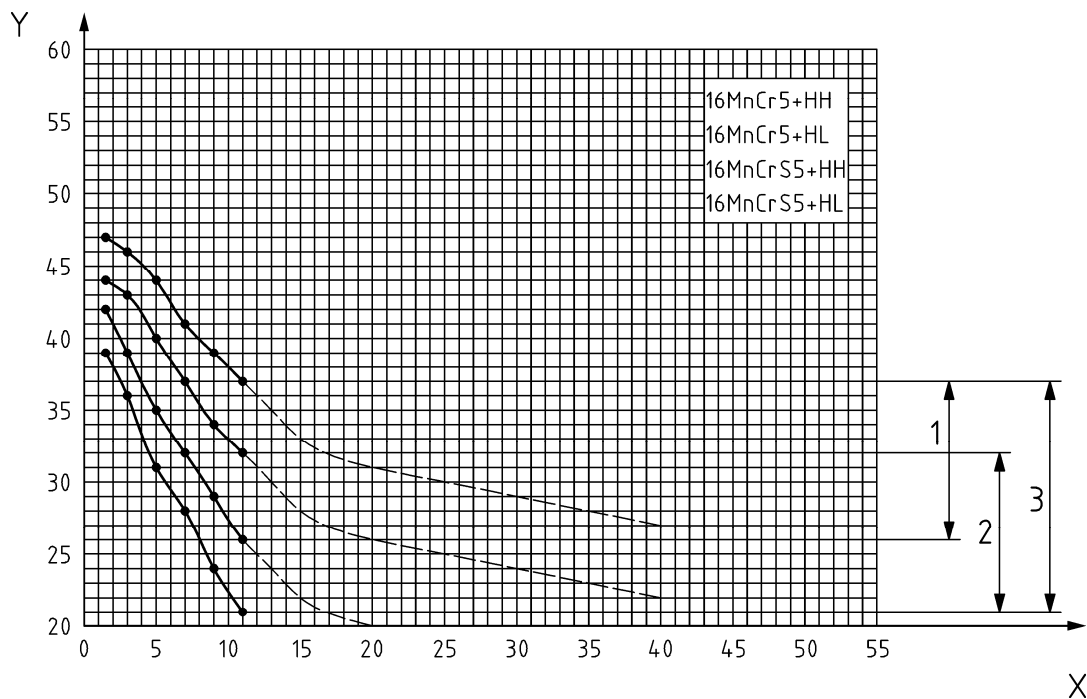
1	2	3	4	5	6
Requirements	See Table	Amount of testing		Sampling and sample preparation ^b	Test method to be used
		Test unit ^a	Number of sample products per test unit		
Chemical composition	3 + 4	C	(The cast analysis is given by the manufacturer; for product analysis see A.3).		
Hardenability	5 + 6	C	1	1	In cases of dispute, the test piece shall be prepared as follows: a) For diameters $d \leq 40$ mm, the test piece shall be produced by machining. b) For diameters $40 \text{ mm} < d \leq 150$ mm, the bar shall be reduced by forging to a diameter of 40 mm or a test piece with diameter 40 mm shall be taken so that its axis is 20 mm below the surface. c) For diameters $d > 150$ mm, the test piece shall be taken so that its axis is 20 mm below the surface. In all other cases, unless otherwise agreed at the time of ordering, the sampling method is left to the discretion of the manufacturer. 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. In accordance with EN ISO 642. The quenching temperature shall be as specified in Table 8. The hardness values shall be determined in accordance with method C in EN ISO 6508-1.
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 x 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 x the thickness from the end and 0,25 x 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 ISO 6506-1. In accordance with EN ISO 6506-1.
Hardness in the condition +N	7	C	1	1	The test shall be performed near the surface In accordance with EN ISO 6506-1.
^a 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.					
^b The general conditions for selection and preparation of samples and test pieces should be in accordance with EN ISO 377 and EN ISO 14284.					



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

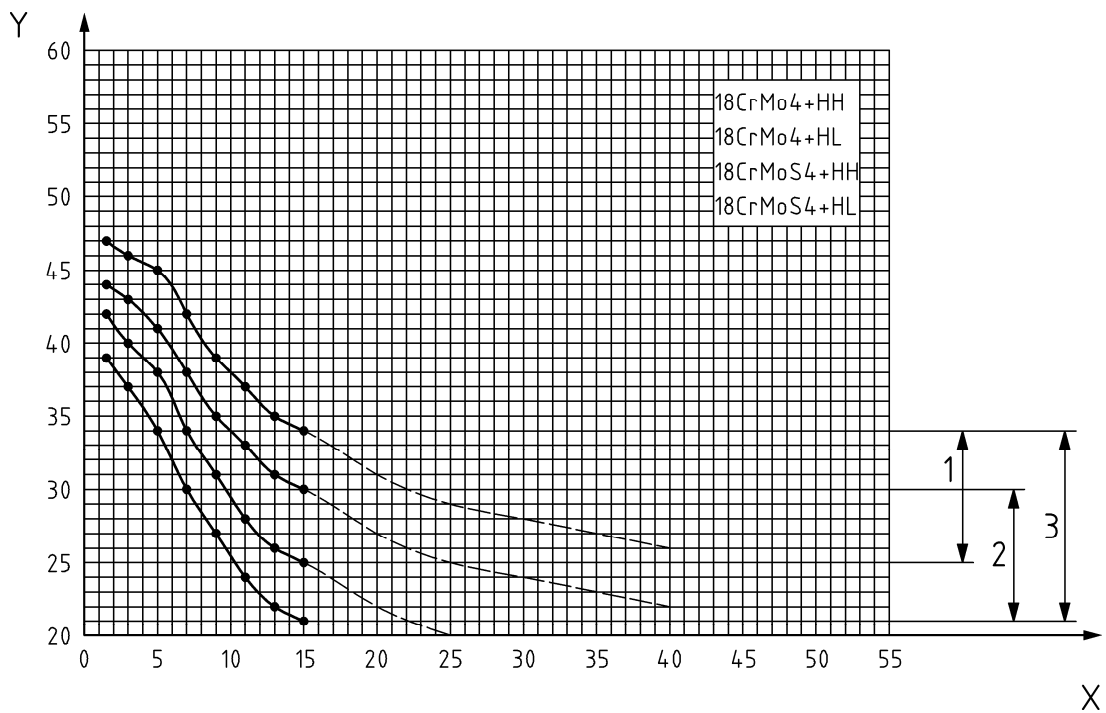
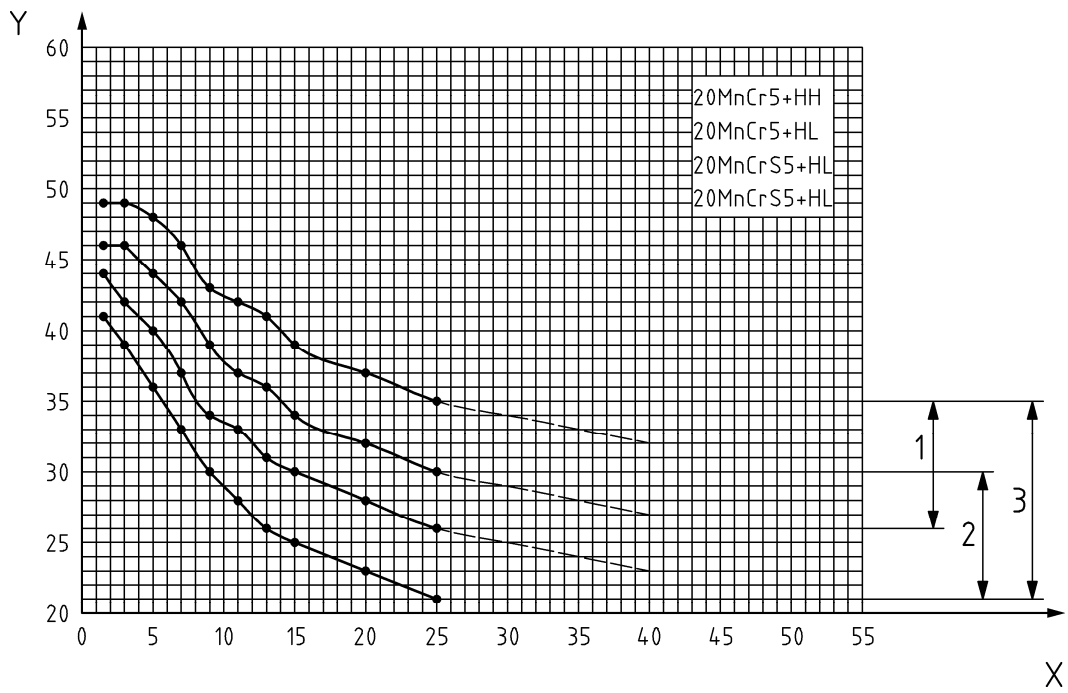
Figure 1 — Scatter bands for the Rockwell-C hardness in the end quench hardenability test



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

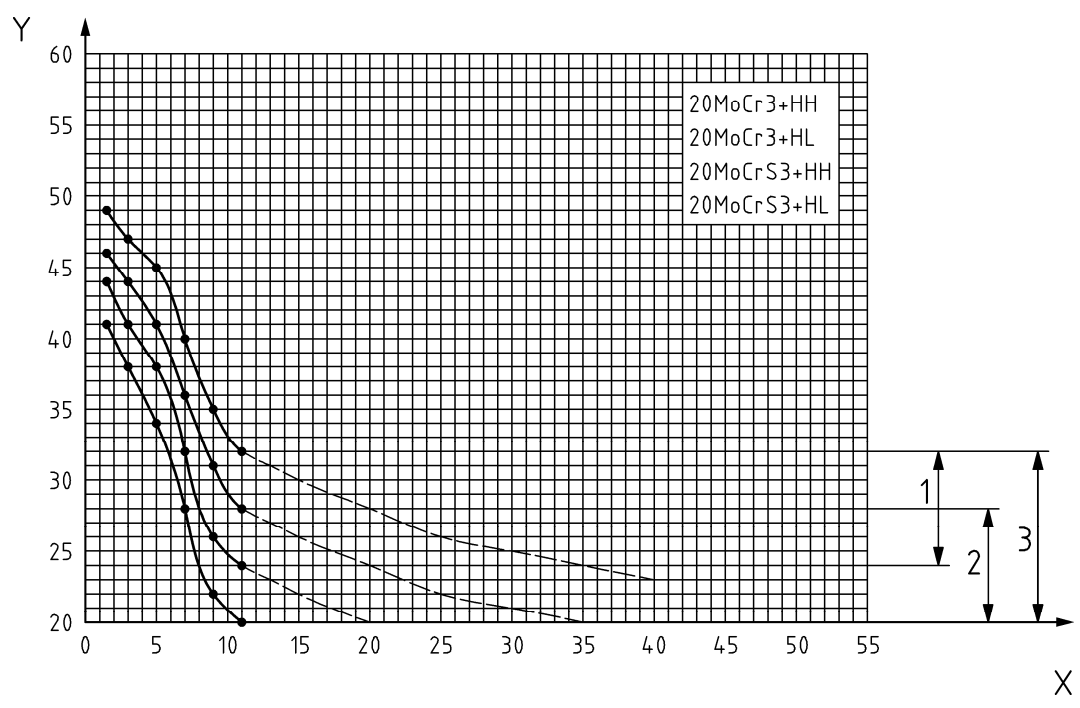
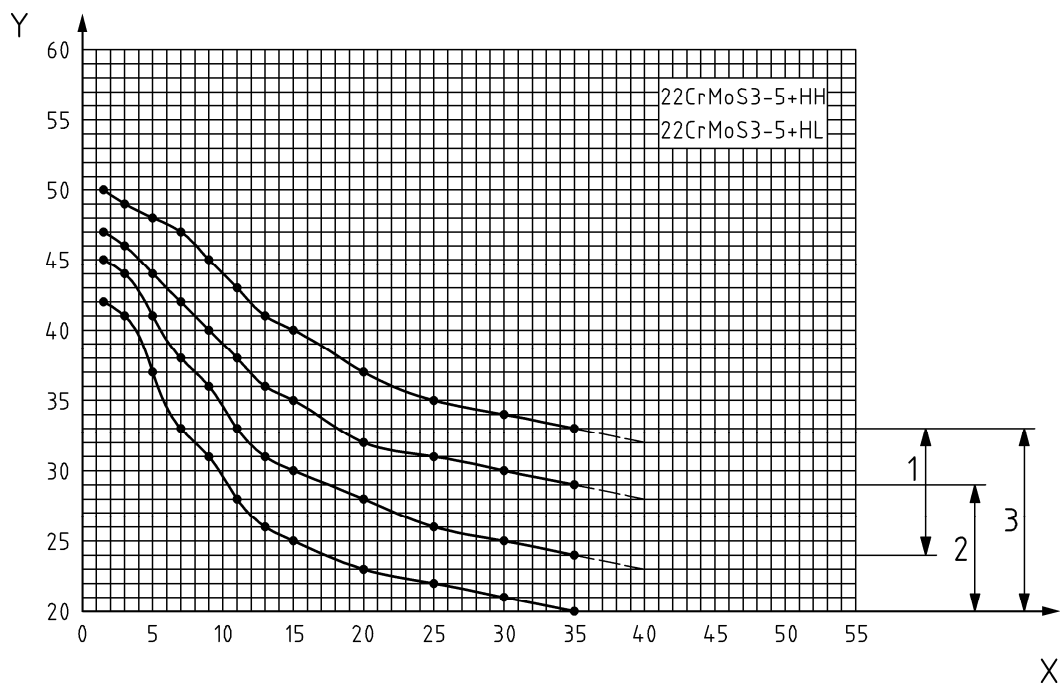
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
(continued)



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

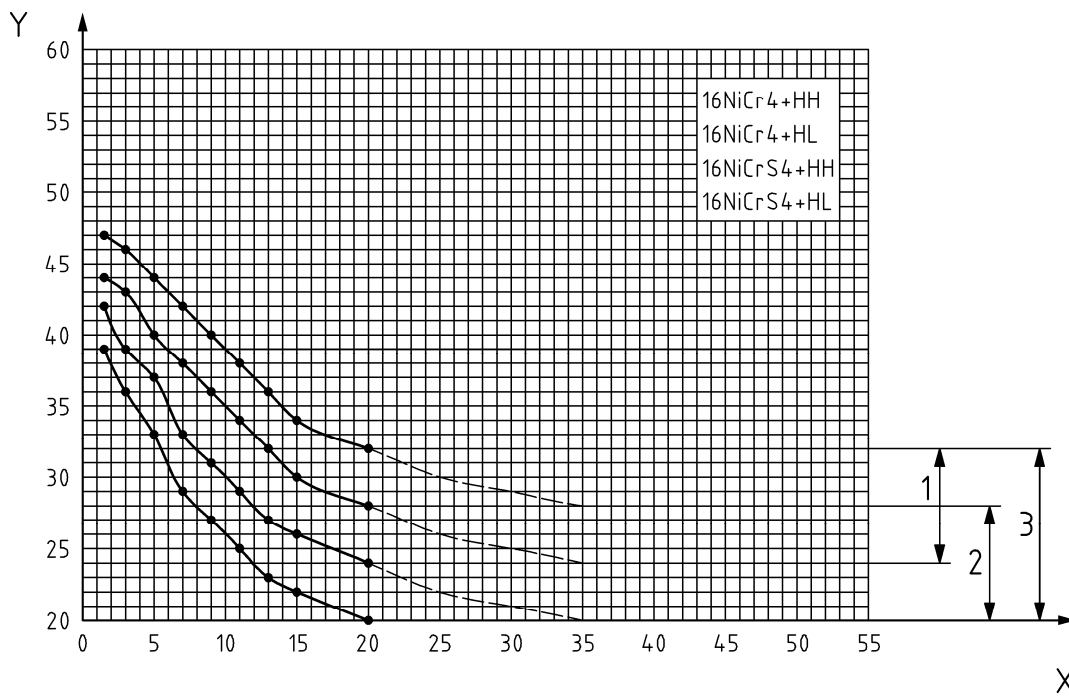
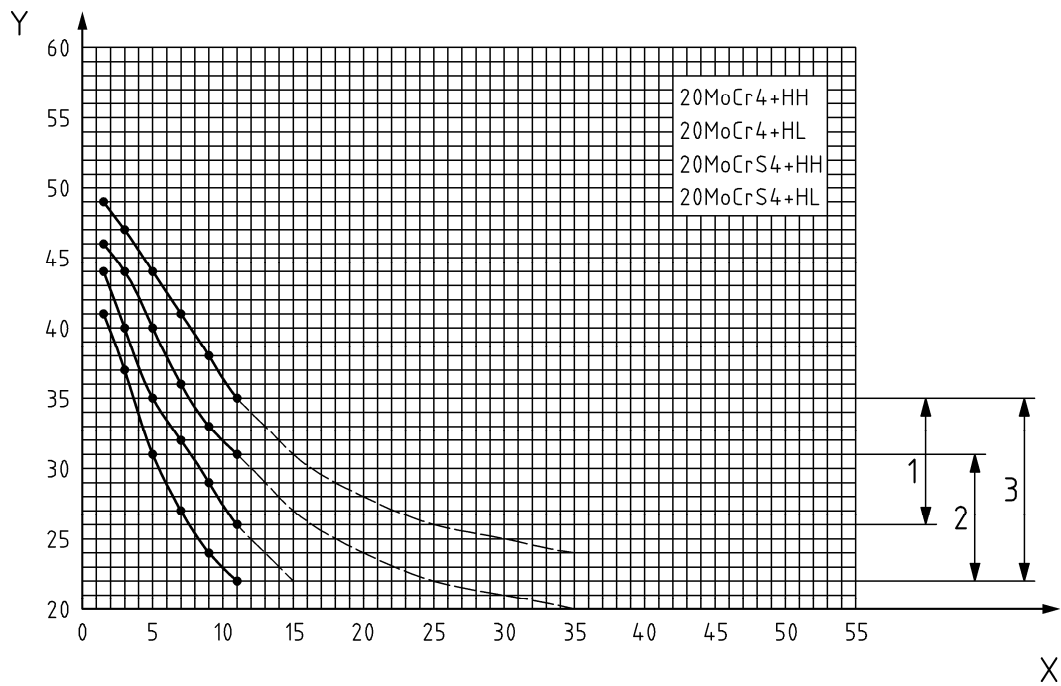
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
(continued)



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

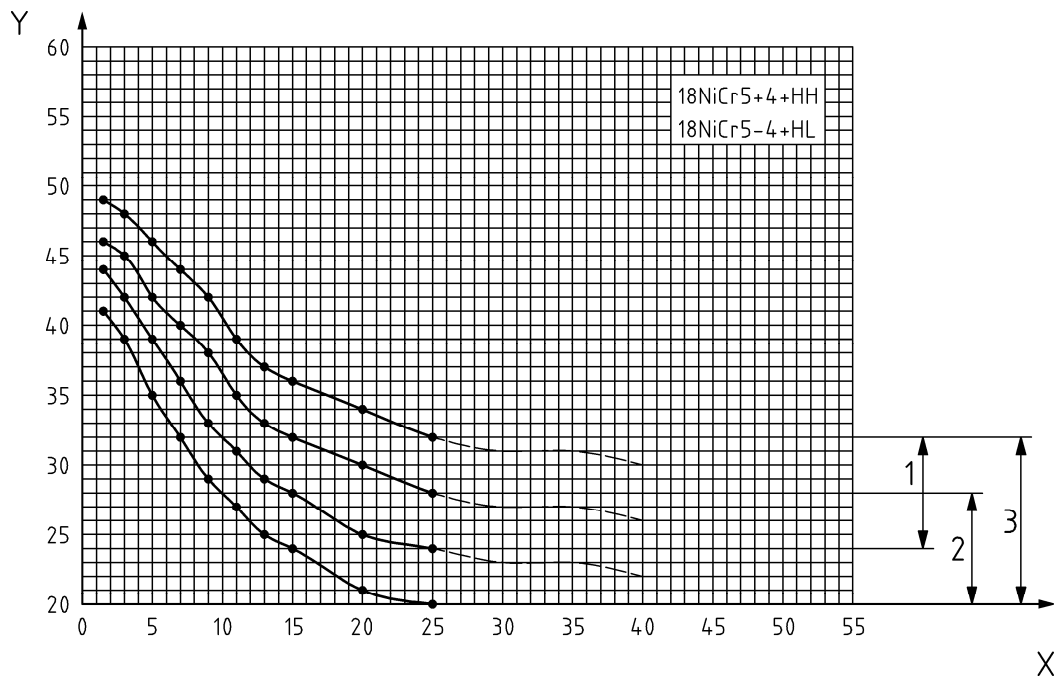
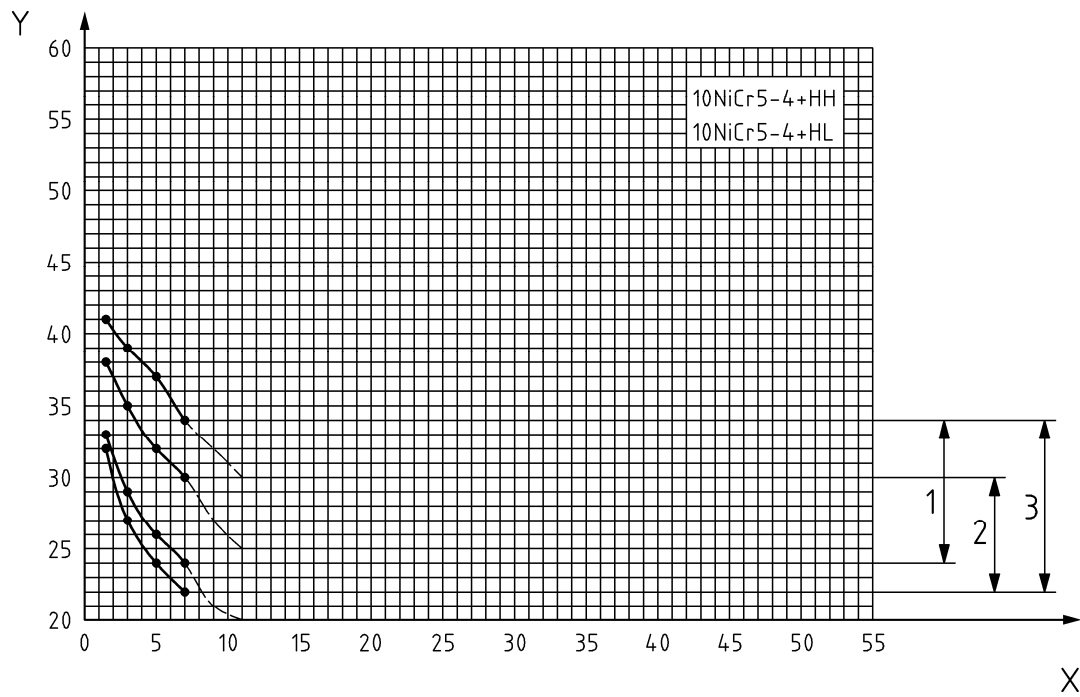
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
(continued)



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

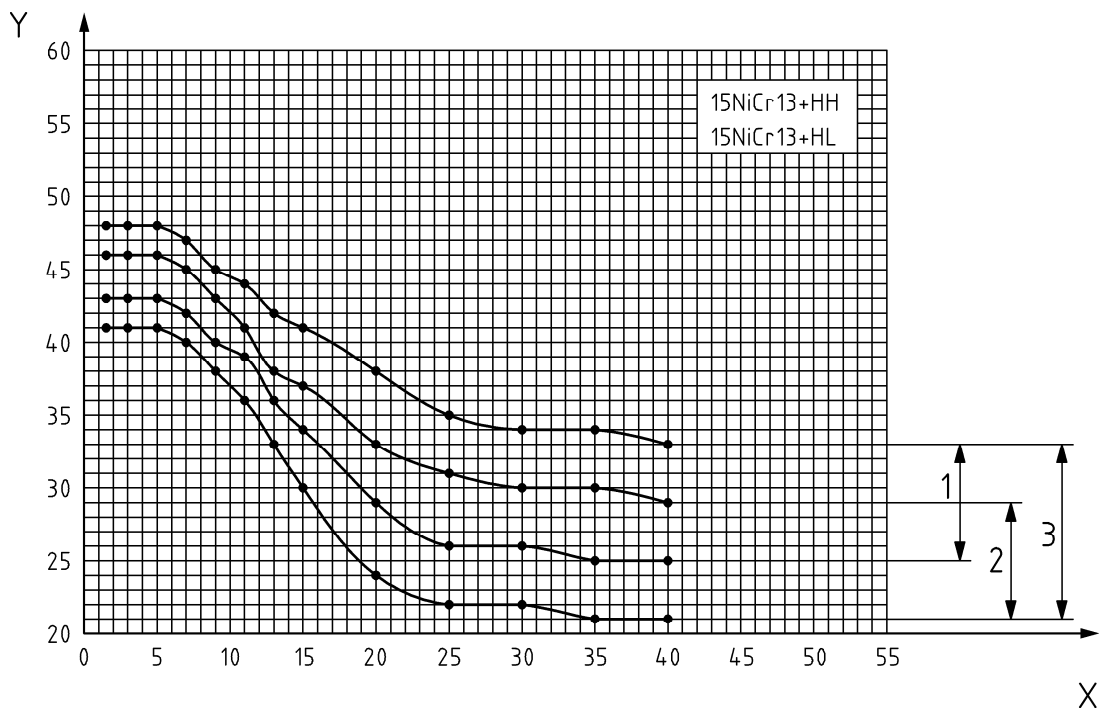
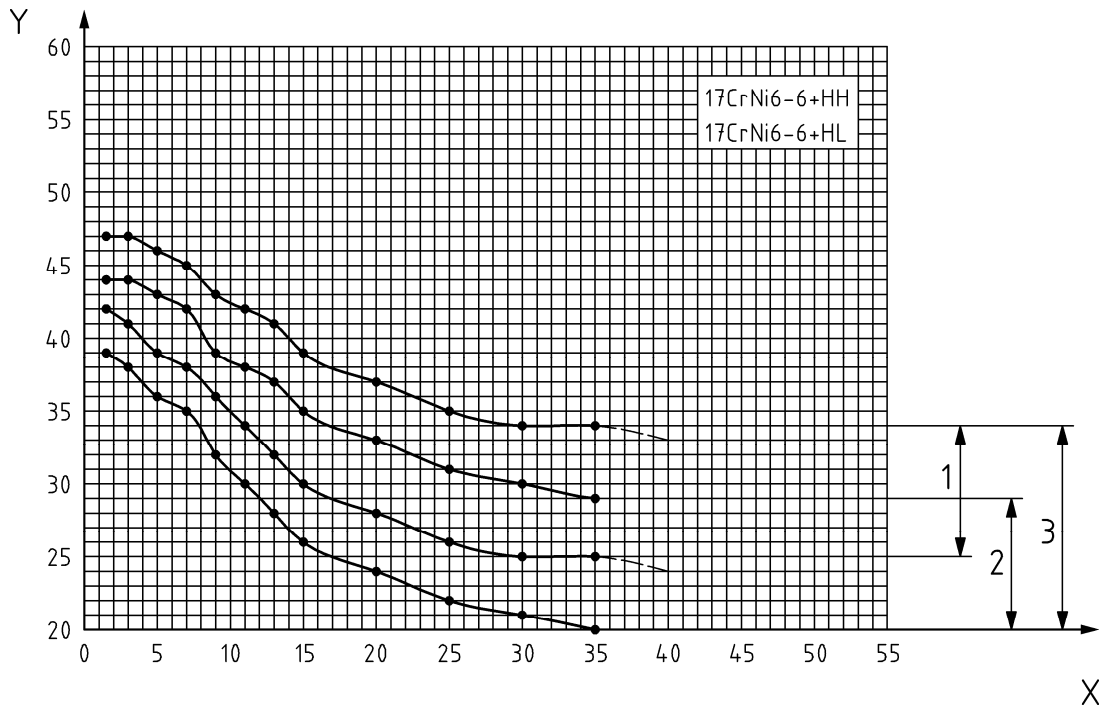
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
(continued)



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

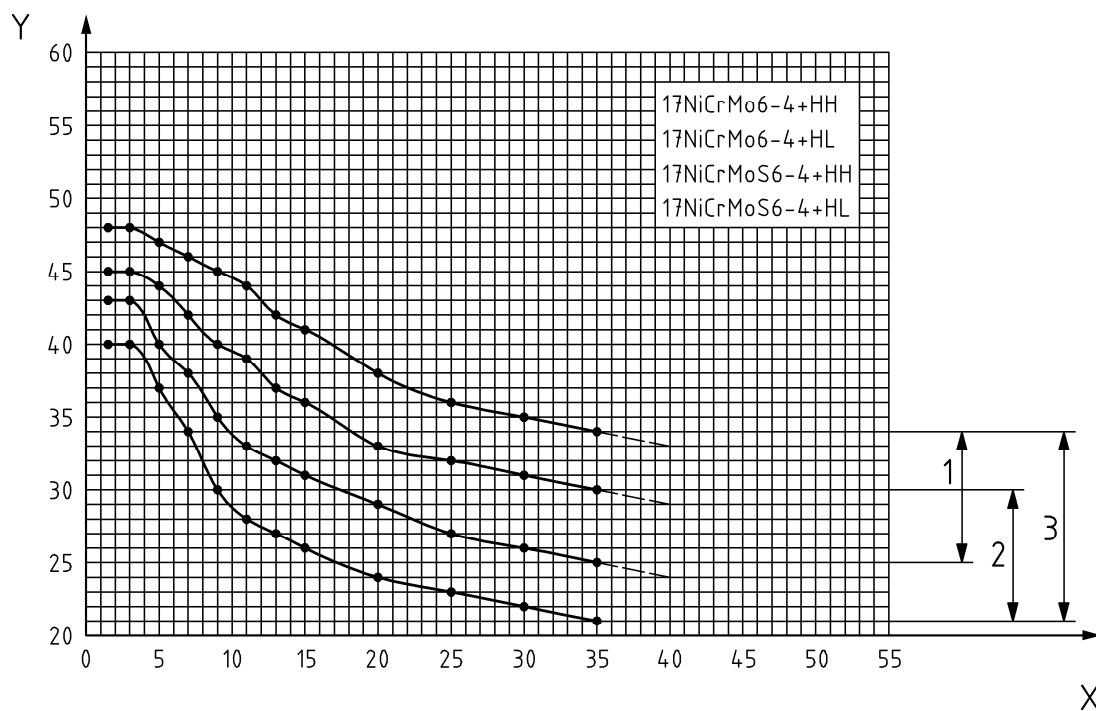
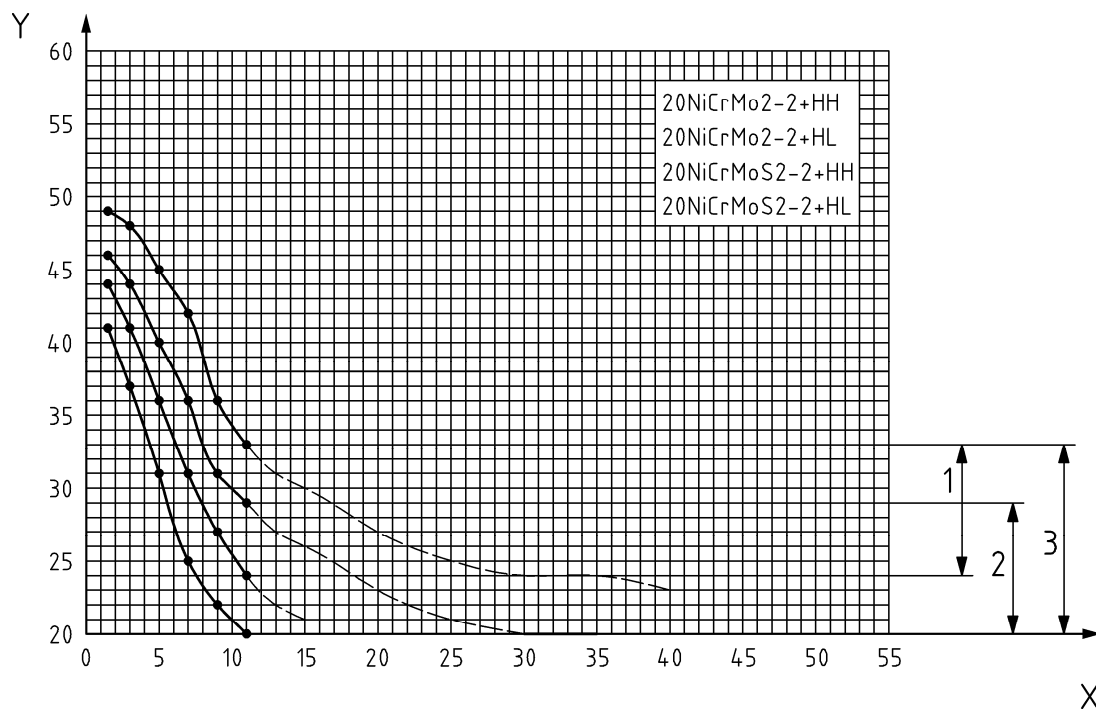
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
 (continued)



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
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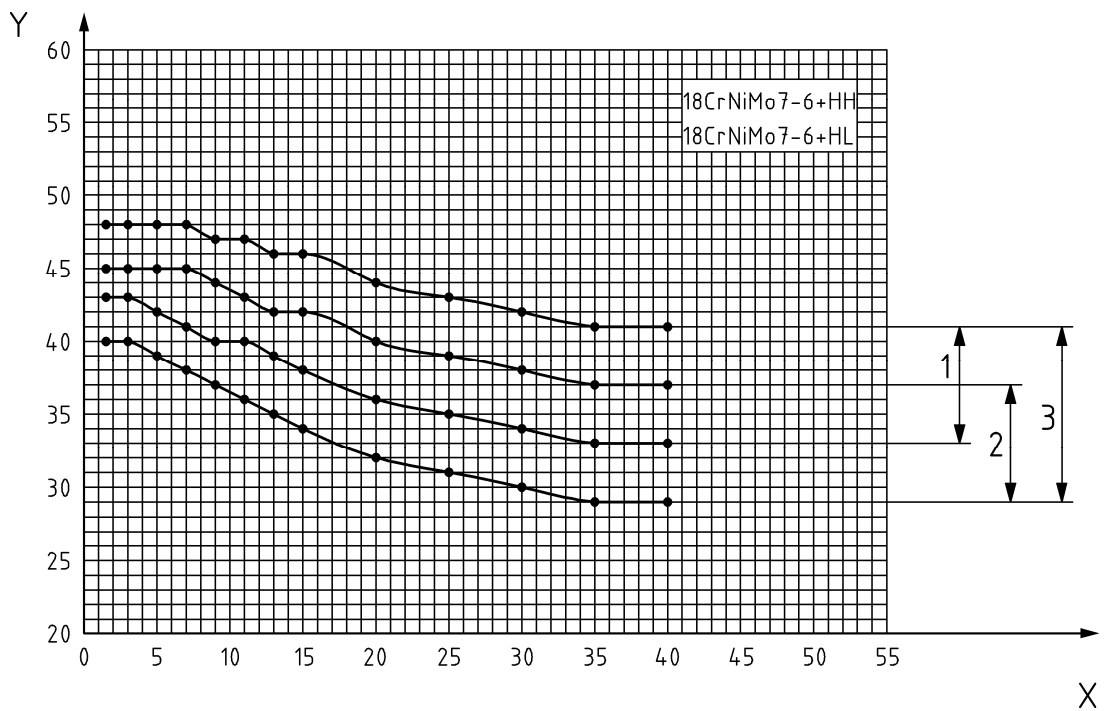
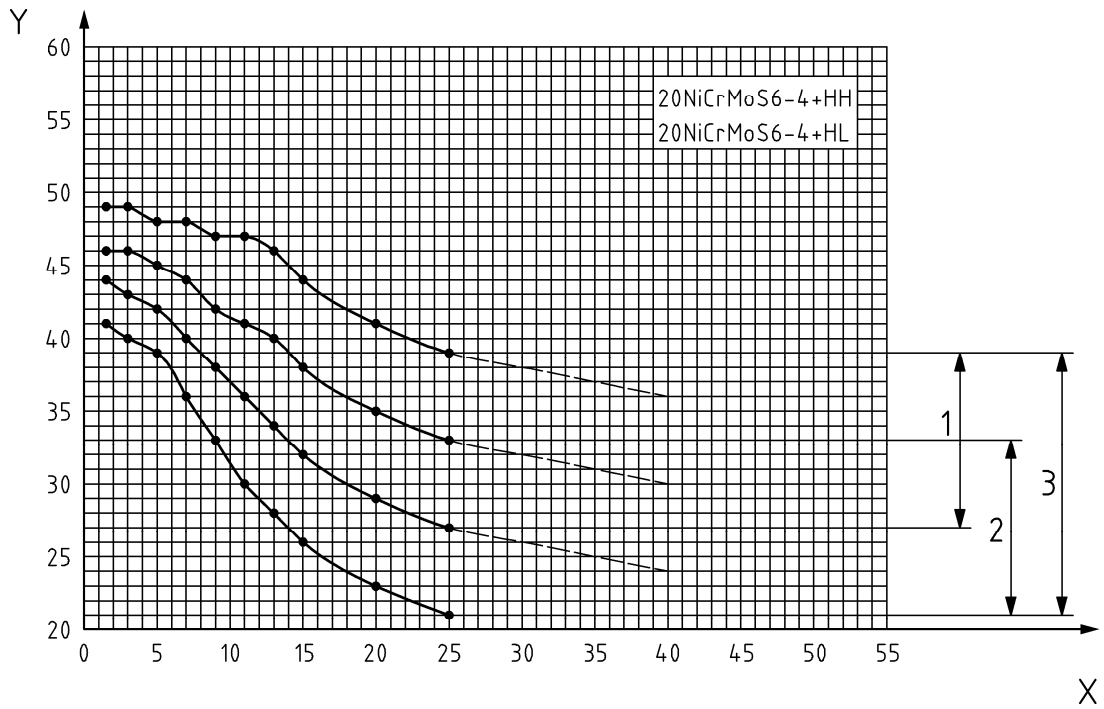
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
(continued)



Key

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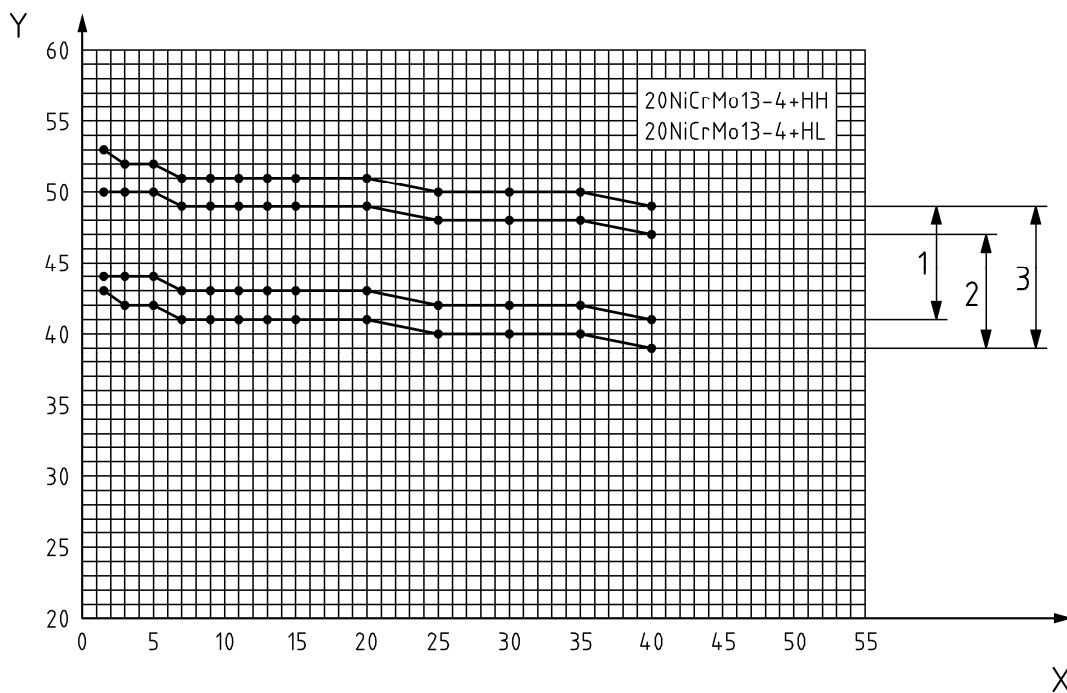
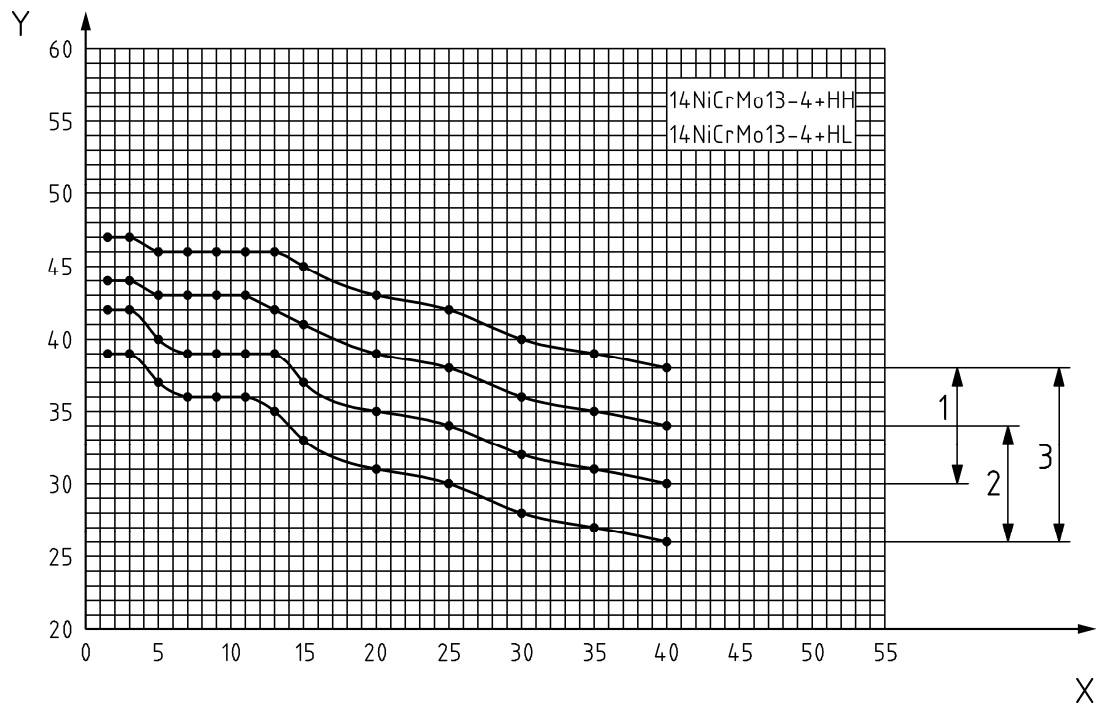
Figure 1 — Scatter bands for the Rockwell - C hardness in the end quench hardenability test
(continued)



Key

- X Distance from quenched end of test piece, mm
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- 3 H-grade

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



Key

- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

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

Annex A (normative)

Options

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

A.1.1 Microscopic inclusions

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

NOTE The requirements for non metallic inclusions content apply in every case; however, verification requires a special agreement.

A.1.2 Macroscopic inclusions

This requirement is applicable for the verification of the macroscopic inclusions in special steels. If verification is agreed then the method and acceptance limits shall be agreed at the time of enquiry and order.

A.2 Non-destructive testing

Steel flat products of thickness equal to or greater than 6 mm shall be tested ultrasonically in accordance with EN 10160 and steel bars shall be tested ultrasonically in accordance with EN 10308. Other products shall be non-destructively tested in accordance with a method to be agreed at the time of enquiry and order and to acceptance criteria also to be agreed 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 EN ISO 14284. In cases of dispute about the analytical method, the chemical composition shall be determined in accordance with a reference method taken from one of the European Standards in prCEN/TR 10261.

A.4 Fine grain steel

Fine grain steel shall have an austenite grain size of 5 or finer. If specific testing is ordered, the grain size requirement is to be verified by determining the aluminium content or micrographically. The fine grain structure is normally achieved, when the total aluminium content is a minimum of 0,018 %. In such a case the micrographic investigation is not necessary. The aluminium content shall be given in the inspection document.

Otherwise one test piece per cast shall be inspected for the determination of the austenitic grain size. Sampling and sample preparation shall be as specified in EN ISO 643. The steel shall be tested in accordance with the Mc-Quaid-Ehn method described in EN ISO 643 and the grain structure shall be considered satisfactory if 70 % of the area is within the specified size limits.

Unless otherwise agreed at the time of enquiry and order, the grain size shall be determined from a carburised specimen. Carburisation shall be achieved by maintaining the specimen in carburising powder at 925 °C ± 10 °C for 6 h. This is generally done by keeping the carburising chamber at 925 °C ± 10 °C for 8 h, including a pre-heating period. In most cases, a carburised layer of approximately 1 mm is obtained. After carburising,

cooling the specimen at a rate slow enough ensures the cementite precipitating on the grain boundaries of the hypoeutectoid zone of the carburised layer.

A.5 Reduction ratio and deformation ratio

If the central soundness of the hot rolled or forged products is important, the purchaser must be aware that a minimum reduction ratio (referred to the cross section) for long products or a minimum thickness deformation ratio (referred to the thickness) for flat products is necessary. In this case a minimum reduction ratio or a minimum thickness deformation ratio of e.g. 4:1 may be agreed at the time of enquiry and order (see 6.3).

A.6 Special marking

The products shall be specially marked (e.g. by bar coding in accordance with EN 606) in a way agreed upon at the time of enquiry and order.

Annex B (informative)

Dimensional standards applicable to products complying with this European Standard

For rod:

EN 10017, *Steel rod for drawing and/or cold rolling – Dimensions and tolerances*

EN 10108, *Round steel rod for cold heading and cold extrusion – Dimensions and tolerances*

For hot rolled bars:

EN 10058, *Hot rolled flat steel bars for general purposes – Dimensions and tolerances on shape and dimensions*

EN 10059, *Hot rolled square steel bars for general purposes – Dimensions and tolerances on shape and dimensions*

EN 10060, *Hot rolled round steel bars for general purposes - Dimensions and tolerances on shape and dimensions*

EN 10061, *Hot rolled hexagon steel bars for general purposes - Dimensions and tolerances on shape and dimensions*

For hot rolled strip and sheet/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 shap.*

EN 10051:1991, *Continuously hot rolled uncoated plate, sheet and strip of non-alloy and alloy steels – Tolerances on dimensions and shape*

Annex C (normative)

Determining the microscopic non-metallic inclusions content

The microscopic non-metallic inclusions in special steels shall be tested in accordance with EN 10247. The method of assessment and the requirements for determining the non-metallic inclusions content are to be defined at the time of enquiry and order.

If there is no agreement at the time of enquiry and order the average field method calculated for area inclusions with restricted evaluation (K_{aR}) shall be used and following requirements are applicable (see Table C.1).

Table C.1 — Requirements for the microscopic non-metallic inclusions content assessment in accordance with EN 10247

Average field method (K) calculated for area inclusions (a) with restricted values (R): K_{aR} ($\mu\text{m}^2/\text{mm}^2$)	
Restricted values for	Types ¹⁾ EB – aluminium oxides EC – silicates ED – globular oxides EAD – heterogeneous inclusions, partly encapsulated
	Row 4 and bigger ($> 22 \mu\text{m}$)
Limit	$K_{aR} \leq 40$ ($\mu\text{m}^2/\text{mm}^2$) for EB + EC + ED + EAD

NOTE The above mentioned method to measure the non-metallic inclusions content was introduced due to the publication of EN 10247:2007 and was first applied in this European Standard. Since customers have to gain experience in the subsequent processing of these special steels with the application of the new measurement method it must be stated that a certain transition period seems to be necessary. During the transition period reference may be made to EN 10084:1998

1) EB – aluminium oxides (columns 7-10 of fig. 5, EN 10247:2007), EC – silicates (columns 1-5 of fig. 5, EN 10247:2007), ED – globular oxides (column 6 of fig. 5, EN 10247:2007), EAD – heterogeneous inclusions, partly encapsulated (columns 1-6 of fig. 5, EN 10247:2007), see also figure A.2 of EN 10247:2007.

Annex D
(informative)

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

Table D.1

EN 10084		ISO 683-11:1987	Germany		Finland	France	Italy	Spain	Sweden	United Kingdom
Steel name	Steel number		Steel name	Steel 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	-	22CrMoS3 5	1.7333	-	-	-	-	-	-
20MoCr3	1.7320	-	-	-	-	-	-	-	-	-
20MoCrS3	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	21NiCrMoS2	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	-	-	-	-	-
14NiCrMo13-4	1.6657	-	-	-	-	-	16NiCrMo12	-	-	-
20NiCrMo13-4	1.6660	-	-	-	-	-	-	-	-	-

BS EN 10084:2008
EN 10084:2008 (E)

Annex E
 (informative)

Classification of steel grades according to minimum tensile strength as a function of diameter after hardening and tempering at 200 °C

Table E.1

R _m _{min} MPa	d ≤ 16 mm	16 mm < d ≤ 40 mm	40 mm < d ≤ 100 mm
1400	20NiCrMo13-4	20NiCrMo13-4	20NiCrMo13-4
1200	20MnCr5, 20MnCrS5, 17NiCrMo6-4, 17NiCrMoS6-4, 20NiCrMoS6-4 18NiCr5-4, 17CrNi6-6, 18CrNiMo7-6, 14NiCrMo13-4		
1100	22CrMoS3-5 18CrMo4, 18CrMoS4, 20NiCrMo2-2, 20NiCrMoS2-2	18NiCr5-4, 17CrNi6-6, 18CrNiMo7-6	
1000	15NiCr13 16MnCr5, 16MnCrS5, 16MnCrB5 16NiCr4, 16NiCrS4	20NiCrMoS6-4 14NiCrMo13-4 17NiCrMo6-4, 17NiCrMoS6-4	
900	20MoCr3, 20MoCrS3, 20MoCr4, 20MoCrS4 28Cr4, 28CrS4, 10NiCr5-4	20MnCr5, 20MnCrS5 22CrMoS3-5	
800	C16E, C16R, 17Cr3, 17CrS3, C15E, C15R	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
700			15NiCr13 20MnCr5, 20MnCrS5
600		28Cr4, 28CrS4, 10NiCr5-4 17Cr3, 17CrS3	18CrMo4, 18CrMoS4, 20NiCrMo2-2, 20NiCrMoS2-2 28Cr4, 28CrS4, 16MnCr5, 16MnCrS5, 16MnCrB5
500		C16E, C16R C15E, C15R	
400	C10E, C10R	C10E, C10R	10NiCr5-4

Bibliography

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

- [1] EN 10083-1, *Steels for quenching and tempering - Part 1: General technical delivery conditions*
- [2] EN 10083-2, *Steels for quenching and tempering - Part 2: Technical delivery conditions for non alloy steels*
- [3] EN 10083-3, *Steels for quenching and tempering - Part 3: Technical delivery conditions for alloy steels*
- [4] EN 10085, *Nitriding steels – Technical delivery conditions*
- [5] EN 10087, *Free-cutting steels – Technical delivery conditions for semi-finished products, hot-rolled bars and rods*
- [6] EN 10089, *Hot-rolled steels for quenched and tempered springs – Technical delivery conditions*
- [7] EN 10263-1, *Steel rod, bars and wire for cold heading and cold extrusion - Part 1: General technical delivery conditions*
- [8] EN 10263-3, *Steel rod, bars and wire for cold heading and cold extrusion - Part 3: Technical delivery conditions for case hardening steels*
- [9] EN 10277-1, *Bright steel products - Technical delivery conditions - Part 1: General*
- [10] EN 10277-4, *Bright steel products - Technical delivery conditions - Part 4: Case-hardening steels*
- [11] ISO 683-11, *Heat-treatable steels, alloy steels and free-cutting steels - Part 11: Wrought case-hardening steels*

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