

Steels for quenching and tempering —

Part 3: Technical delivery conditions for alloy steels

The European Standard EN 10083-3:2006 has the status of a
British Standard

ICS 77.140.10

National foreword

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

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Foreword

This document (EN 10083-3:2006) 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of an identical text or by endorsement, at the latest by February 2007, and conflicting national standards shall be withdrawn at the latest by February 2007.

This document supersedes EN 10083-3:1995.

Together with Part 1 and Part 2 of this standard this part 3 is a revision of the following European Standards:

EN 10083-1:1991 +A1:1996, *Quenched and tempered steels – Part 1: Technical delivery conditions for special steels*

EN 10083-2:1991 +A1:1996, *Quenched and tempered steels – Part 2: Technical delivery conditions for unalloyed quality steels*

EN 10083-3:1995, *Quenched and tempered steels – Part 3: Technical delivery conditions for boron steels*

and of

EURONORM 86-70, *Flame and induction hardening steels – Quality specifications*

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

1 Scope

This part of EN 10083, in addition to Part 1, specifies the technical delivery requirements for:

- semi-finished products, hot formed, e.g. blooms, billets, slabs (see NOTES 2 and 3 in EN 10083-1:2006, Clause 1),
- bars (see NOTE 2 in EN 10083-1:2006, Clause 1),
- rod,
- wide flats,
- hot-rolled strip and sheet/plate,
- forgings (see NOTE 2 in EN 10083-1:2006, Clause 1),

manufactured from the direct hardening alloy steels for quenching and tempering and the alloy flame and induction hardening steels and supplied in one of the heat treatment conditions given for the different types of products in Table 1, lines 2 to 6, and in one of the surface conditions given in Table 2.

The steels are generally intended for the fabrication of quenched and tempered, flame or induction hardened machine parts.

The requirements for mechanical properties given in this document are restricted to the sizes given in Table 8.

NOTE This document does not apply for bright steel products. For bright steel products EN 10277-1 and EN 10277-5 apply.

In special cases, variations in these technical delivery requirements or additions to them may be agreed at the time of enquiry and order (see Annex A).

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 10002-1, *Metallic materials – Tensile testing – Part 1: Method of test at ambient temperature*

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

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

EN 10027-2, *Designation systems for steels – Part 2: Numerical system*

EN 10045-1, *Metallic materials – Charpy impact test – Part 1: Test method*

EN 10083-1:2006, *Steels for quenching and tempering – Part 1: General technical delivery conditions*

EN 10160, *Ultrasonic testing of steel flat product of thickness equal 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: Plate 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*

CR 10261, *ECISS Information Circular 11 – 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 3887, *Steels – Determination of depth of decarburization (ISO 3887:2003)*

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

EN ISO 6508-1:2005, *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 document, the terms and definitions given in EN 10083-1:2006 apply.

4 Classification and designation

4.1 Classification

All steel grades are classified according to EN 10020 as alloy special steels.

4.2 Designation

4.2.1 Steel names

For the steel grades covered by this document, the steel names as given in the relevant tables are allocated in accordance with EN 10027-1.

4.2.2 Steel numbers

For the steel grades covered by this document, the steel numbers as given in the relevant tables are allocated in accordance with EN 10027-2.

5 Information to be supplied by the purchaser

5.1 Mandatory information

See EN 10083-1:2006, 5.1.

5.2 Options

A number of options are specified in this document and listed below. If the purchaser does not indicate his wish to implement any of these options, the supplier shall act in accordance with the basic specification.

- a) any particular heat treatment condition (see 6.3.2);
- b) any particular surface condition (see 6.3.3);
- c) any verification of the product analysis (see 7.1.2.2 and A.5);
- d) any requirement to the hardenability (+H, +HH, +HL) (see 7.1.3) and if agreed the information about calculation of the hardenability (see 10.3.2);
- e) any verification of mechanical properties of reference test pieces in the quenched and tempered (+QT) condition (see A.1);
- f) any verification of fine grain size (see 7.4 and A.2);
- g) any requirements for the verification of non-metallic inclusion content (see 7.4 and A.3);
- h) any requirement for internal soundness (see 7.5 and A.4);
- i) any requirement relating to surface quality (see 7.6.3);
- j) any requirement regarding the permissible depth of decarburization (see 7.6.4);
- k) suitability of bars and rod for bright drawing (see 7.6.5);
- l) any requirement relating to removal of surface defects (see 7.6.6);
- m) inspection of surface condition and dimensions shall be carried out by the purchaser at the manufacturer's works (see 8.1.4);
- n) any requirement concerning special marking of the products (see 11 and A.6).

EXAMPLE

20 round bars with the nominal diameter 20 mm and the nominal length of 8000 mm according to EN 10060 made of steel grade 25CrMo4 (1.7218) according to EN 10083-3 in the heat treatment condition +A, inspection certificate 3.1 as specified in EN 10204.

20 round bars EN 10060 - 20x8000

EN 10083-3 – 25CrMo4+A

EN 10204 - 3.1

or

20 round bars EN 10060 - 20x8000

EN 10083-3 – 1.7218+A

EN 10204 - 3.1

6 Manufacturing process

6.1 General

The manufacturing process of steel and of the products is left to the discretion of the manufacturer with the restrictions given by the requirements in 6.2 to 6.4.

6.2 Deoxidation

All steels shall be killed.

6.3 Heat treatment and surface condition at delivery

6.3.1 Untreated condition

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

NOTE Depending on the product shape and dimensions, not all steel grades can be delivered in the hot worked untreated condition (e.g. steel grade 30CrNiMo8).

6.3.2 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 6.

6.3.3 Particular surface condition

If so agreed at the time of enquiry and order, the products shall be delivered with one of the particular surface conditions given in Table 2, lines 3 to 7.

6.4 Cast separation

The products shall be delivered separated by cast.

7 Requirements

7.1 Chemical composition, hardenability and mechanical properties

7.1.1 General

Table 1 shows the combinations of usual heat-treatment conditions at delivery, product forms and requirements as specified in Tables 3 to 8.

Except where the steels are ordered in the quenched and tempered condition, the steels may be supplied with or without hardenability requirements (see Table 1, columns 8 and 9).

7.1.2 Chemical composition

7.1.2.1 The chemical composition determined by cast analysis shall comply with the values in Table 3.

7.1.2.2 Permissible deviations between the limiting values for cast analysis and the values for product analysis are given in Table 4.

The product analysis shall be carried out when specified at the time of the order (see A.5).

7.1.3 Hardenability

Where the steel is ordered by using the symbols for normal (+H) or restricted (+HL, +HH) hardenability requirements, the hardenability values given in Table 5 or Table 6 shall apply.

7.1.4 Mechanical properties

Where the steel is ordered without hardenability requirements, the requirements for mechanical properties specified in Table 8 for the quenched and tempered condition apply.

In this case the hardenability values given in Table 5 are for guidance purposes only.

The mechanical property values given in Table 8 apply to test pieces in the quenched and tempered condition which have been taken and prepared in accordance with EN 10083-1:2006, Figure 1 or Figures 2 and 3 (see also footnote a in Table 1).

7.1.5 Surface hardness

For the hardness of surface hardened zones of steels intended for flame and induction hardening the specifications in Table 9 apply.

7.2 Machinability

All steels delivered in the soft annealed (+A) condition are machinable. Where improved machinability is required, the grades with a specified sulphur range should be ordered and/or with a specific treatment to improve machinability (e.g. Ca treatment), see also Table 3, footnote c.

7.3 Shearability of semi-finished products and bars

7.3.1 Under suitable conditions (avoiding local stress peaks, pre-heating, application of blades with a profile adapted to that of the product, etc.) all steels are shearable in the soft-annealed (+A) condition (see, however, footnote f to Table 7).

7.3.2 Steel grades without boron up to steel grade 42CrMoS4 and the boron-alloy steel grades 33MnCrB5-2 and 39MnCrB6-2 (see Table 7) and the corresponding grades with requirements on hardenability (see Tables 5 and 6) are shearable under suitable conditions, if they are supplied in the "treated to improve shearability (+S)" condition with the hardness requirements as specified in Table 7.

7.3.3 Under suitable conditions steel grades 20MnB5, 30MnB5, 38MnB5 and 27MnCrB5-2 and the corresponding grades with requirements on hardenability (see Table 5) are shearable in the untreated condition.

7.4 Structure

7.4.1 All steels shall have a fine grain structure with an austenite grain size of 5 or finer, when tested in accordance with EN ISO 643. For verification see A.2.

7.4.2 The steels shall have a degree of cleanness corresponding to the special steel quality (see A.3 and EN 10083-1:2006, Annex E).

7.5 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.4).

7.6 Surface quality

7.6.1 All products shall have a smooth finish appropriate to the manufacturing processes applied, see also 6.3.3.

7.6.2 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.

7.6.3 Where appropriate, requirements relating to the surface quality of the products shall be agreed upon at the time of enquiry and order, if possible with reference to European Standards.

Sheet/plate and wide flats are delivered with surface class A, subclass 1 according to EN 10163-2 unless otherwise agreed at the time of enquiry and order.

Bars and rods are delivered with surface class A according to EN 10221 unless otherwise agreed at the time of enquiry and order.

7.6.4 Requirements relating to the permissible depth of decarburization may be agreed at the time of enquiry and order.

The depth of decarburization shall be determined in accordance with the micrographic method specified in EN ISO 3887.

7.6.5 If suitability of bars and rods for bright drawing is required, this shall be agreed at the time of enquiry and order.

7.6.6 The removal of surface defects by welding shall only be permitted with the approval of the customer or his representative.

If surface discontinuities are repaired, the method and maximum depth of removal shall be agreed at the time of enquiry and order.

7.7 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 EN 10083-1:2006, Annex D).

8 Inspection

8.1 Testing procedures and types of documents

8.1.1 Products complying with this document 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 For the information to be included in a test report, see EN 10083-1:2006, 8.1.2.

8.1.3 For the information to be included in an inspection certificate, see EN 10083-1:2006 8.1.3.

8.1.4 Unless otherwise agreed at the time of the order, inspection of surface quality and dimensions shall be carried out by the manufacturer.

8.2 Frequency of testing

8.2.1 Sampling

Sampling shall be in accordance with Table 10.

8.2.2 Test units

The test units and the extent of testing shall be in accordance with Table 10.

8.3 Tests to be carried out for specific inspection

8.3.1 Verification of hardenability, hardness and mechanical properties

For steels being ordered without hardenability requirements, i.e. without the symbol +H, +HH or +HL in the designation, the hardness requirements or mechanical properties given for the relevant heat-treatment condition in Table 1, Column 8, subclause 2, shall with the following exception be verified. The requirement given in Table 1, Footnote a (mechanical properties of reference test pieces), is only to be verified if supplementary requirement A.1 is ordered.

For steels being ordered with the symbol +H, +HH or +HL in the designation (see Tables 5 and 6), unless otherwise agreed, only hardenability requirements according to Table 5 or 6 shall be verified.

8.3.2 Visual and dimensional inspection

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

9 Preparation of samples and test pieces

9.1 Selection and preparation of samples for chemical analysis

The preparation of samples for product analysis shall be in accordance with EN ISO 14284.

9.2 Location and orientation of samples and test pieces for mechanical tests

9.2.1 Preparation of samples

Preparation of samples shall be in accordance with Table 10 and EN 10083-1:2006, 9.2.1.

9.2.2 Preparation of test pieces

Preparation of test pieces shall be in accordance with Table 10 and EN 10083-1:2006, 9.2.2.

9.3 Location and preparation of samples for hardness and hardenability tests

See Table 10.

9.4 Identification of samples and test pieces

Samples and test pieces shall be marked so that the original products and their location and orientation in the product is known.

10 Test methods

10.1 Chemical analysis

See EN 10083-1:2006, 10.1.

10.2 Mechanical tests

See Table 10 and EN 10083-1:2006, 10.2.

10.3 Hardness and hardenability tests

10.3.1 Hardness in treatment conditions +A and +S

For products in treatment conditions +A (soft annealed) and +S (treated to improve shearability), the hardness shall be measured in accordance with EN ISO 6506-1.

10.3.2 Verification of hardenability

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 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. The temperature for quenching shall comply with table 11. The hardness values shall be determined in accordance with EN ISO 6508-1, scale C.

10.3.3 Surface hardness

The surface hardness of steels after flame or induction hardening (see Table 9) shall be determined in accordance with EN ISO 6508-1, scale C.

10.4 Retests

See EN 10083-1:2006, 10.4.

11 Marking, labelling, packaging

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 as specified in Tables 3 to 8

1	2	3	4	5	6	7	8	9	
1	Heat treatment condition at delivery	Symbol	x indicates applicable for				Applicable requirements if the steel is ordered with the designation given in		
			Semi-finished products	Bars	Rod	Flat products	Hammer and drop forgings	Table 3	Table 5 or 6
								8.1	8.2
2	Untreated	none or +U	x	x	x	x	Chemical composition according to Tables 3 and 4	As in columns 8.1 and 8.2 (see footnote b in Table 3)	Hardenability values according to Table 5 or 6
3	Treated to improve shearability	+S	x	-	x	-			
4	Soft annealed	+A	x	x	x ^b	x			
5	Quenched and tempered	+QT	x	x	x ^b	x			
6	Others	Other treatment conditions, e.g. certain annealing conditions to achieve a certain structure may be agreed at the time of enquiry and order. The treatment condition annealed for spheroidal carbide (+AC) as required for cold upsetting and cold extrusion is covered by EN 10263-4.					Mechanical properties according to	Table 8	Not Applicable
^a	For deliveries in the untreated condition and in the "treated to improve shearability" and "soft annealed" condition, the mechanical properties specified in Table 8 shall be achievable for the ruling end cross-section after appropriate heat treatment (for verification on reference test pieces, see A.1).								
^b	It is not possible to deliver all dimensions of flat products in this heat-treatment condition.								

Table 2 — Surface condition at delivery

	1	2	3	4	5	6	7	8	9
1	Surface condition at delivery		Symbol	x indicates in general applicable for					Notes
				Semi-finished products (such as blooms, billets)	Bars	Rod	Flat products	Hammer and drop forgings (see note 2 in EN 10083-1:2006, Clause 1)	
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	x	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	-
7		Others	-	-	-	-	-	-	-
^a In addition, it may be agreed that the products be oiled or, where appropriate, limed or phosphated.									

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

Steel designation		Chemical composition % by mass ^{a,b}									
Name	Number	C	Si max.	Mn	P max.	S	Cr	Mo	Ni	V	B
Steels without boron ^c											
38Cr2	1.7003	0,35 to 0,42	0,40	0,50 to 0,80	0,025	max. 0,035	0,40 to 0,60	-	-	-	-
46Cr2	1.7006	0,42 to 0,50	0,40	0,50 to 0,80	0,025	max. 0,035	0,40 to 0,60	-	-	-	-
34Cr4	1.7033	0,30 to 0,37	0,40	0,60 to 0,90	0,025	max. 0,035	0,90 to 1,20	-	-	-	-
34CrS4	1.7037					0,020 to 0,040					
37Cr4	1.7034	0,34 to 0,41	0,40	0,60 to 0,90	0,025	max. 0,035	0,90 to 1,20	-	-	-	-
37CrS4	1.7038					0,020 to 0,040					
41Cr4	1.7035	0,38 to 0,45	0,40	0,60 to 0,90	0,025	max. 0,035	0,90 to 1,20	-	-	-	-
41CrS4	1.7039					0,020 to 0,040					
25CrMo4	1.7218	0,22 to 0,29	0,40	0,60 to 0,90	0,025	max. 0,035	0,90 to 1,20	0,15 to 0,30	-	-	-
25CrMoS4	1.7213					0,020 to 0,040					
34CrMo4	1.7220	0,30 to 0,37	0,40	0,60 to 0,90	0,025	max. 0,035	0,90 to 1,20	0,15 to 0,30	-	-	-
34CrMoS4	1.7226					0,020 to 0,040					
42CrMo4	1.7225	0,38 to 0,45	0,40	0,60 to 0,90	0,025	max. 0,035	0,90 to 1,20	0,15 to 0,30	-	-	-
42CrMoS4	1.7227					0,020 to 0,040					
50CrMo4	1.7228	0,46 to 0,54	0,40	0,50 to 0,80	0,025	max. 0,035	0,90 to 1,20	0,15 to 0,30	-	-	-
34CrNiMo6	1.6582	0,30 to 0,38	0,40	0,50 to 0,80	0,025	max. 0,035	1,30 to 1,70	0,15 to 0,30	1,30 to 1,70	-	-
30CrNiMo8	1.6580	0,26 to 0,34	0,40	0,50 to 0,80	0,025	max. 0,035	1,80 to 2,20	0,30 to 0,50	1,80 to 2,20	-	-
35NiCr6	1.5815	0,30 to 0,37	0,40	0,60 to 0,90	0,025	max. 0,025	0,80 to 1,10	-	1,20 to 1,60	-	-
36NiCrMo16	1.6773	0,32 to 0,39	0,40	0,50 to 0,80	0,025	max. 0,025	1,60 to 2,00	0,25 to 0,45	3,6 to 4,1	-	-
39NiCrMo3	1.6510	0,35 to 0,43	0,40	0,50 to 0,80	0,025	max. 0,035	0,60 to 1,00	0,15 to 0,25	0,70 to 1,00	-	-
30NiCrMo16-6	1.6747	0,26 to 0,33	0,40	0,50 to 0,80	0,025	max. 0,025	1,20 to 1,50	0,30 to 0,60	3,3 to 4,3	-	-
51CrV4	1.8159	0,47 to 0,55	0,40	0,70 to 1,10	0,025	max. 0,025	0,90 to 1,20	-	0,10 to 0,25	-	-
Steels with boron											
20MnB5	1.5530	0,17 to 0,23	0,40	1,10 to 1,40	0,025	max. 0,035	-	-	-	-	0,0008 to 0,0050
30MnB5	1.5531	0,27 to 0,33	0,40	1,15 to 1,45	0,025	max. 0,035	-	-	-	-	0,0008 to 0,0050
38MnB5	1.5532	0,36 to 0,42	0,40	1,15 to 1,45	0,025	max. 0,035	-	-	-	-	0,0008 to 0,0050
27MnCrB5-2	1.7182	0,24 to 0,30	0,40	1,10 to 1,40	0,025	max. 0,035	0,30 to 0,60	-	-	-	0,0008 to 0,0050
33MnCrB5-2	1.7185	0,30 to 0,36	0,40	1,20 to 1,50	0,025	max. 0,035	0,30 to 0,60	-	-	-	0,0008 to 0,0050
39MnCrB6-2	1.7189	0,36 to 0,42	0,40	1,40 to 1,70	0,025	max. 0,035	0,30 to 0,60	-	-	-	0,0008 to 0,0050

^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 and for boron to have its effect on the hardenability. All reasonable precautions shall be taken to prevent the addition of such elements from scrap or other material used in the manufacture which affect the hardenability, mechanical properties and applicability.

^b Where requirements are made on hardenability (see Tables 5 and 6) or on the mechanical properties in the quenched and tempered condition (see Table 8), slight deviations from the limits for the cast analysis are permissible, except for the elements carbon, phosphorus and sulfur; the deviations shall not exceed the specifications of 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)) may be supplied on request. In this case the upper limit for the manganese content may be increased by 0,15 %.

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	$\leq 0,55$	$\pm 0,02$
Si	$\leq 0,40$	$+ 0,03$
Mn	$\leq 1,00$	$\pm 0,04$
	$> 1,00$ $\leq 1,70$	$\pm 0,05$
P	$\leq 0,025$	$+ 0,005$
S	$\leq 0,040$	$+ 0,005^b$
Cr	$\leq 2,00$	$\pm 0,05$
	$> 2,00$ $\leq 2,20$	$\pm 0,10$
Mo	$\leq 0,30$	$\pm 0,03$
	$> 0,30$ $\leq 0,60$	$\pm 0,04$
Ni	$\leq 2,00$	$\pm 0,05$
	$> 2,00$ $\leq 4,3$	$\pm 0,07$
V	$\leq 0,25$	$\pm 0,02$
B	$\leq 0,0050$	$\pm 0,0003$
^a $\pm$ 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. ^b For steels with a specified sulphur range of 0,020% to 0,040% according to cast analysis, the permissible deviation is $\pm 0,005\%$.		

Table 5 — Limiting values for the "C" scale Rockwell hardness for special steel grades with (normal) hardenability requirements (+H grades)

Steel designation		Symbol	Limits of range	Distance in mm from quenched end																
Name	Number			1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50		
Steels without boron																				
38Cr2	1.7003	+H	max.	59	57	54	49	43	39	37	35	32	30	27	-	-	-	-		
			min.	51	46	37	29	25	22	20	-	-	-	-	-	-	-	-		
46Cr2	1.7006	+H	max.	63	61	59	57	53	47	42	39	36	33	32	-	-	-	-		
			min.	54	49	40	32	28	25	23	22	20	-	-	-	-	-	-		
34Cr4	1.7033	+H	max.	57	57	56	54	52	49	46	44	39	37	35	34	33	32	31		
			min.	49	48	45	41	35	32	29	27	23	21	20	-	-	-	-		
37Cr4	1.7034	+H	max.	59	59	58	57	55	52	50	48	42	39	37	36	35	34	33		
			min.	51	50	48	44	39	36	33	31	26	24	22	20	-	-	-		
41Cr4	1.7035	+H	max.	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35		
			min.	53	52	50	47	41	37	34	32	29	26	23	21	-	-	-		
25CrMo4	1.7218	+H	max.	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31		
			min.	44	43	40	37	34	32	29	27	23	21	20	-	-	-	-		
34CrMo4	1.7220	+H	max.	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39		
			min.	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24		
42CrMo4	1.7225	+H	max.	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45		
			min.	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29		
50CrMo4	1.7228	+H	max.	65	65	64	64	63	63	63	62	61	60	58	57	55	54	54		
			min.	58	58	57	55	54	53	51	48	45	41	39	38	37	36	36		
34CrNiMo6	1.6582	+H	max.	58	58	58	58	57	57	57	57	57	57	57	57	57	57	57		
			min.	50	50	50	50	49	48	48	48	48	47	47	47	46	45	44		
30CrNiMo8	1.6580	+H	max.	56	56	56	56	55	55	55	55	55	54	54	54	54	54	54		
			min.	48	48	48	48	47	47	47	46	46	45	45	44	44	43	43		
35NiCr6	1.5815	+H	max.	58	58	58	57	57	55	55	55	53	53	50	50	-	-	-		
			min.	49	49	49	48	48	44	44	44	40	40	35	35	-	-	-		
36NiCrMo16	1.6773	+H	max.	57	56	56	56	56	56	55	55	55	55	55	55	55	55	55		
			min.	50	49	48	48	48	48	47	47	47	47	47	47	47	47	47		
39NiCrMo3	1.6510	+H	max.	60	60	59	58	58	57	57	56	55	52	51	49	48	46	45		
			min.	52	51	50	49	48	46	44	43	39	36	34	33	32	31	30		

Table 5 – (continued)

Steel designation		Symbol	Limits of range	Distance in mm from quenched end																
Name		Number		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50		
Steels without boron (<i>continued</i>)																				
30NiCrMo16-6	1.6747	+H	max.	55	55	55	54	54	54	54	54	53	53	53	53	53	53	53		
			min.	47	47	47	46	46	46	46	46	45	45	45	45	45	45	45	45	
			max.	65	65	64	64	63	63	63	62	62	62	61	60	60	59	58	58	
			min.	57	56	56	55	53	52	50	48	44	41	37	35	34	33	32	32	
Steels with boron																				
20MnB5	1.5530	+H	max.	50	49	49	49	47	45	43	41	33	27	-	-	-	-	-		
			min.	42	41	40	37	30	22	-	-	-	-	-	-	-	-	-	-	
30MnB5	1.5531	+H	max.	56	55	55	54	53	51	50	47	40	37	33	-	-	-	-		
			min.	47	46	45	44	42	39	36	31	22	-	-	-	-	-	-	-	
38MnB5	1.5532	+H	max.	60	60	59	58	57	57	55	53	48	41	37	33	31	-	-		
			min.	52	51	50	49	47	44	41	35	28	24	20	-	-	-	-	-	
27MnCrB5-2	1.7182	+H	max.	55	55	55	54	54	53	52	51	47	44	40	37	-	-	-		
			min.	47	46	45	44	43	41	39	36	30	24	20	-	-	-	-	-	
33MnCrB5-2	1.7185	+H	max.	57	57	57	57	57	56	55	54	53	50	47	45	-	-	-		
			min.	48	47	47	46	45	44	43	41	36	31	25	20	-	-	-	-	
39MnCrB6-2	1.7189	+H	max.	59	59	59	59	58	58	58	58	57	57	56	55	54	-	-		
			min.	51	51	51	51	50	50	50	49	47	45	40	35	32	-	-	-	

Table 6 — Limiting values for the C scale Rockwell hardness for special steel grades with restricted hardenability scatter bands (+HH and +HL grades)

Steel designation		Symbol	Limits of range	Distance in mm from quenched end																
Name	Number			1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50		
38Cr2	1.7003	+HH	max.	59	57	54	49	43	39	37	35	32	30	27	-	-	-	-		
			min.	54	50	43	36	31	28	26	24	21	-	-	-	-	-	-		
		+HL	max.	56	53	48	42	37	33	31	29	26	24	21	-	-	-	-	-	
			min.	51	46	37	29	25	22	20	-	-	-	-	-	-	-	-	-	
46Cr2	1.7006	+HH	max.	63	61	59	57	53	47	42	39	36	33	32	-	-	-	-		
			min.	57	53	46	40	36	32	29	28	25	22	21	-	-	-	-		
		+HL	max.	60	57	53	49	45	40	36	33	31	28	27	-	-	-	-	-	
			min.	54	49	40	32	28	25	23	22	20	-	-	-	-	-	-	-	
34Cr4	1.7033	+HH	max.	57	57	56	54	52	49	46	44	39	37	35	34	33	32	31		
			min.	52	51	49	45	41	38	35	33	28	26	25	24	23	22	21		
34Cr4S	1.7037	+HL	max.	54	54	52	50	46	43	40	38	34	32	30	29	28	27	26		
			min.	49	48	45	41	35	32	29	27	23	21	20	-	-	-	-		
37Cr4	1.7034	+HH	max.	59	59	58	57	55	52	50	48	42	39	37	36	35	34	33		
			min.	54	53	51	48	44	41	39	37	31	29	27	25	24	23	22		
37CrS4	1.7038	+HL	max.	56	56	55	53	50	47	44	42	37	34	32	31	30	29	28		
			min.	51	50	48	44	39	36	33	31	26	24	22	20	-	-	-		
41Cr4	1.7035	+HH	max.	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35		
			min.	56	55	53	51	47	43	41	39	35	31	29	27	26	25	24		
41CrS4	1.7039	+HL	max.	58	58	57	55	52	50	47	45	40	37	34	32	31	30	29		
			min.	53	52	50	47	41	37	34	32	29	26	23	21	-	-	-		
25CrMo4	1.7218	+HH	max.	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31		
			min.	47	46	44	41	39	37	34	32	28	26	24	23	22	22	22		
25CrMoS4	1.7213	+HL	max.	49	49	47	46	43	41	38	36	32	30	29	28	27	27	27		
			min.	44	43	40	37	34	32	29	27	23	21	20	-	-	-	-		
34CrMo4	1.7220	+HH	max.	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39		
			min.	52	52	51	49	46	44	42	40	36	34	32	31	30	29	29		
34CrMoS4	1.7226	+HL	max.	54	54	54	52	51	49	47	46	42	39	38	36	35	35	34		
			min.	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24		
42CrMo4	1.7225	+HH	max.	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45		
			min.	56	56	55	54	52	48	46	44	41	39	38	36	36	35	34		
42CrMoS4	1.7227	+HL	max.	58	58	58	57	56	54	53	51	49	46	44	42	41	40	40		
			min.	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29		

Table 6 – (continued)

Steel designation		Symbol	Limits of range	Distance in mm from quenched end HRC Hardness																
Name	Number			1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50		
50CrMo4	1.7228	+HH	max.	65	64	64	64	63	63	63	62	61	60	58	57	55	54	54		
			min.	60	59	58	57	56	55	55	53	50	47	45	44	43	42	42		
		+HL	max.	63	63	62	61	60	60	59	57	56	54	52	51	49	48	48		
			min.	58	58	57	55	54	53	51	48	45	41	39	38	37	36	36		
34CrNiMo6	1.6582	+HH	max.	58	58	58	58	57	57	57	57	57	57	57	57	57	57	57		
			min.	53	53	53	53	52	51	51	51	51	50	50	50	50	49	48		
		+HL	max.	55	55	55	55	54	54	54	54	54	54	54	54	53	53	53		
			min.	50	50	50	50	49	48	48	48	48	47	47	47	46	45	44		
30CrNiMo8	1.6580	+HH	max.	56	56	56	56	55	55	55	55	55	54	54	54	54	54	54		
			min.	51	51	51	51	50	50	50	49	49	48	48	47	47	47	47		
		+HL	max.	53	53	53	53	52	52	52	52	52	51	51	51	51	51	50		
			min.	48	48	48	48	47	47	47	46	46	45	45	44	44	43	43		
35NiCr6	1.5815	+HH	max.	58	58	58	57	57	55	55	55	53	53	53	50	-	-	-		
			min.	53	53	53	52	52	50	50	50	48	48	45	45	-	-	-		
		+HL	max.	54	54	54	53	53	49	49	49	45	45	40	40	-	-	-		
			min.	49	49	49	48	48	44	44	44	40	40	35	35	-	-	-		
36NiCrMo16	1.6773	+HH	max.	57	56	56	56	56	56	55	55	55	55	55	55	55	55	55		
			min.	52	51	51	51	51	51	50	50	50	50	50	50	50	50	50		
		+HL	max.	55	54	53	53	53	53	52	52	52	52	52	52	52	52	52		
			min.	50	49	48	48	48	48	47	47	47	47	47	47	47	47	47		
39NiCrMo3	1.6510	+HH	max.	60	60	59	58	58	57	57	56	55	52	51	49	48	46	45		
			min.	55	54	53	52	51	50	48	47	44	41	40	38	37	36	35		
		+HL	max.	57	57	56	55	55	53	53	52	50	47	45	44	43	41	40		
			min.	52	51	50	49	48	46	44	43	39	36	34	33	32	31	30		
30NiCrMo16-6	1.6747	+HH	max.	55	55	55	54	54	54	54	54	53	53	53	53	53	53	53		
			min.	50	50	50	49	49	49	49	49	48	48	48	48	48	48	48		
		+HL	max.	52	52	52	51	51	51	51	51	50	50	50	50	50	50	50		
			min.	47	47	47	46	46	46	46	46	45	45	45	45	45	45	45		
51CrV4	1.8159	+HH	max.	65	65	64	64	63	63	63	62	62	62	61	60	59	58	58		
			min.	60	59	59	58	56	56	54	53	50	48	45	43	43	42	41		
		+HL	max.	62	62	61	61	60	59	59	57	56	55	53	52	51	50	49		
			min.	57	56	56	55	53	52	50	48	44	41	37	35	34	33	32		

Table 7 — Maximum hardness for products to be supplied in the "treated to improve shearability (+S)" or "soft annealed (+A)" condition

Steel designation ^a		Max. HBW in condition ^b	
Name	Number	+S	+A
38Cr2	1.7003	255	207
46Cr2	1.7006	255	223
34Cr4, 34CrS4	1.7033, 1.7037	255	223
37Cr4, 37CrS4	1.7034, 1.7038	255	235
41Cr4, 41CrS4	1.7035, 1.7039	255 ^c	241
25CrMo4, 25CrMoS4	1.7218, 1.7213	255	212
34CrMo4, 34CrMoS4	1.7220, 1.7226	255 ^c	223
42CrMo4, 42CrMoS4	1.7225, 1.7227	255 ^c	241
50CrMo4	1.7228	- ^d	248
34CrNiMo6	1.6582	- ^d	248
30CrNiMo8	1.6580	- ^d	248
35NiCr6	1.5815	- ^d	223
36NiCrMo16	1.6773	- ^d	269
39NiCrMo3	1.6510	- ^d	240
30NiCrMo16-6	1.6747	- ^d	270
51CrV4	1.8159	- ^d	248
20MnB5	1.5530	- ^e	- ^f
30MnB5	1.5531	- ^e	- ^f
38MnB5	1.5532	- ^e	- ^f
27MnCrB5-2	1.7182	- ^e	- ^f
33MnCrB5-2	1.7185	255	- ^f
39MnCrB6-2	1.7189	255	- ^f
^a The values apply also for the steel with hardenability requirements (+H-, +HH- and +HL-grades) covered in Tables 5 and 6; see, however, footnote c. ^b The values are not applicable to slabs which have been continuously cast and not further deformed. ^c Depending on the chemical composition of the cast, and on the dimensions, particularly in the case of the +HH-grades, soft annealing may be necessary. ^d Where the shearability is of importance, this steel should be ordered in the "soft-annealed" condition. ^e Shearable in the untreated condition. ^f Condition +A is not applicable for boron steels.			

Table 8 — Mechanical properties ^a at room temperature in the quenched and tempered condition (+QT)

Steel designation	Mechanical properties for the ruling section (see EN 10083-1:2006, Annex A) with a diameter (<i>d</i>) or for flat products thickness (<i>t</i>) of														
	<i>d</i> ≤ 16 mm <i>t</i> ≤ 8 mm					16 mm < <i>d</i> ≤ 40 mm 8 mm < <i>t</i> ≤ 20 mm					40 mm < <i>d</i> ≤ 100 mm 20 mm < <i>t</i> ≤ 60 mm				
	<i>R_e</i> min.	<i>R_m</i>	<i>A</i> min. %	<i>Z</i> min. %	<i>KV^b</i> min. J	<i>R_e</i> min.	<i>R_m</i>	<i>A</i> min. %	<i>Z</i> min. %	<i>KV^b</i> min. J	<i>R_e</i> min.	<i>R_m</i>	<i>A</i> min. %	<i>Z</i> min. %	<i>KV^b</i> min. J
	MPa ^c	MPa ^c				MPa ^c	MPa ^c				MPa ^c	MPa ^c			
38Cr2	550	800 to 950	14	35	-	450	700 to 850	15	40	35	350	600 to 750	17	45	35
46Cr2	650	900 to 1100	12	35	-	550	800 to 950	14	40	35	400	650 to 800	15	45	35
34Cr4	700	900 to 1100	12	35	-	590	800 to 950	14	40	40	460	700 to 850	15	45	40
34CrS4	1.7033	1.7037													
37Cr4	750	950 to 1150	11	35	-	630	850 to 1000	13	40	35	510	750 to 900	14	40	35
37CrS4	1.7038														
41Cr4	800	1000 to 1200	11	30	-	660	900 to 1100	12	35	35	560	800 to 950	14	40	35
41CrS4	1.7035	1.7039													
25CrMo4	700	900 to 1100	12	50	-	600	800 to 950	14	55	50	450	700 to 850	15	60	50
25CrMoS4	1.7218	1.7213													
34CrMo4	800	1000 to 1200	11	45	-	650	900 to 1100	12	50	40	550	800 to 950	14	55	45
34CrMoS4	1.7220														
42CrMo4	900	1100 to 1300	10	40	-	750	1000 to 1200	11	45	35	650	900 to 1100	12	50	35
42CrMoS4	1.7225														
50CrMo4	900	1100 to 1300	9	40	-	780	1000 to 1200	10	45	30	700	900 to 1100	12	50	30
50CrMoS4	1.7228														
34CrNiMo6	1.6582														
30CrNiMo8	1.6580														
35NiCr6	740	880 to 1080	12	40	-	740	880 to 1080	14	40	35	640	780 to 980	15	40	35
36NiCrMo16	1.6773														
39NiCrMo3	1.6510														
30NiCrMo16-6	1.6747														
51CrV4	1.8159														
20MnB5	1.5530														
30MnB5	1.5531														

Table 8 – (continued)

Steel designation		Mechanical properties for the ruling section (see EN 10083-1:2006, Annex A) with a diameter (d) or for flat products thickness (t) of																													
		d ≤ 16 mm t ≤ 8 mm						16 mm < d ≤ 40 mm 8 mm < t ≤ 20 mm						40 mm < d ≤ 100 mm 20 mm < t ≤ 60 mm						100 mm < d ≤ 160 mm 60 mm < t ≤ 100 mm						160 mm < d ≤ 250 mm 100 mm < t ≤ 160 mm					
		R _e min.	R _m	A min.	Z min.	KV ^b min.	R _e min.	R _m	A min.	Z min.	KV ^b min.	R _e min.	R _m	A min.	Z min.	KV ^b min.	R _e min.	R _m	A min.	Z min.	KV ^b min.	R _e min.	R _m	A min.	Z min.	KV ^b min.					
Name	Name	MPa ^c						MPa ^c						MPa ^c						MPa ^c						MPa ^c					
38MnB5	1.5532	900	1050 to 1250	12	50	-	700	850 to 1050	12	50	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
27MnCrB5-2	1.7182	800	1000 to 1250	14	55	-	750	900 to 1150	14	55	60	700 ^d	800 to 1000 ^d	15 ^d	55 ^d	65 ^d	-	-	-	-	-	-	-	-	-	-	-				
33MnCrB5-2	1.7185	850	1050 to 1300	13	50	-	800	950 to 1200	13	50	50	750 ^d	900 to 1100 ^d	13 ^d	50 ^d	50 ^d	-	-	-	-	-	-	-	-	-	-	-				
39MnCrB6-2	1.7189	900	1100 to 1350	12	50	-	850	1050 to 1250	12	50	40	800 ^d	1000 to 1200 ^d	12 ^d	50 ^d	40 ^d	-	-	-	-	-	-	-	-	-	-	-				
a		R _e : Upper yield strength or, if no yield phenomenon occurs, 0,2 % proof strength R _{p0.2} . R _m : Tensile strength. A: Percentage elongation after fracture (initial gauge length L ₀ = 5,65 √S ₀ ; see Table 10, column 7a, line T4). Z: Reduction in cross section on fracture. KV: Impact strength of longitudinal Charpy-V-notch test pieces (average of 3 individual values shall meet the minimum specified in the table; no individual value shall be lower than 70 % of the minimum shown in the table.)																													
b		For sampling see EN 10083-1:2006 fig.1 and fig.3.																													
c		1 MPa = 1 N/mm ² .																													
d		For 40 mm < d ≤ 60 mm and 20 mm < t ≤ 40 mm.																													

**Table 9 — Surface hardness of steels
after flame or induction hardening**

Steel designation		Surface hardness HRC min.
Name	Number	
46Cr2	1.7006	54
37Cr4/37CrS4	1.7034/1.7038	51
41Cr4/41CrS4	1.7035/1.7039	53
42CrMo4/42CrMo4	1.7225/1.7227	53
50CrMo4	1.7228	58
^a The above values apply for the condition existing after quenching and tempering and surface hardening according to the conditions given in Table 11 followed by stress relieving at 150°C to 180°C for about 1h, and they relate to cross-sections up to 100 mm diameter for the steels 46Cr2, 37Cr4/37CrS4 and 41Cr4/41CrS4, and up to 250 mm diameter for the steels 42CrMo4/42CrMoS4 and 50CrMo4. It should be noted that surface decarburization may lead to lower hardness values in the surface hardened zones.		

Table 10 — Test conditions for the verification of the requirements given in column 2

1 No.	2 Requirements	3 Test unit ^a	4 Extent of testing		5 Number of tests per product	6 Sampling and sample preparation (see in the supplement to this table, line T1 and line ...)	7 Test method to be applied	(Supplement to Table 10, columns 6 and 7)	
			Number of products per test unit					Line	7a Test method to be applied
	See Table							T1	
1	Chemical composition	3 + 4	(The cast analysis is given by the manufacturer, for product analysis see clause A.5 in annex A)					General conditions The general conditions for selection and preparation of test samples and test pieces for steel shall be in accordance with EN ISO 377 and EN ISO 14284.	
2	Hardenability	5 and 6	1	1		T2		T2 End quench hardenability test. In the case of dispute if possible the sampling method given below shall be used: — the test piece shall be produced by machining in the case of diameters ≤ 40 mm; — the bar shall be reduced by forging to a diameter of 40 mm in the case of diameters $> 40 \leq 150$ mm; — in the case of diameters > 150 mm the test piece shall be taken such that, its axis lies 20 mm below the surface. In all other cases, the sampling method which starts from separately cast and subsequently hot worked test ingots or from cast and not hot worked samples is, unless otherwise agreed at the time of enquiry and order, left to the discretion of the manufacturer.	In accordance with EN ISO 642. The temperature for quenching shall comply with Table 11. The hardness values shall be determined in accordance with EN ISO 6508-1, scale C.

Table 10 – (continued)

1 No.	2 Requirements	3 Test unit ^a	4 Extent of testing Number of products per test unit	5 Number of tests per product	6 Sampling and sample preparation (see in the supplement to this table, line T1 and line ...)	7 Test method to be applied	(Supplement to Table 10, columns 6 and 7)	
							Line	7a Test method to be applied
3	Hardness				T3		T3	In accordance with EN ISO 6506-1.
3a	in the condition +S or +A	C +D +T	1	1	T3a		T3a	In cases of dispute, the hardness shall, where possible, be determined at the following point on the surface: — at a distance of 1x diameter from one end of the bar in the case of round bars; — at a distance of 1 x thickness from one end and 0,25 x thickness from one longitudinal edge of the product in the case of bars with square or rectangular cross-section and also in the case of flat products. If it should be impossible to comply with the above, e.g. in the case of hammer or drop forgings, the most appropriate position for the hardness indentations shall be agreed at the time of ordering. Specimen preparation shall be in accordance with EN ISO 6506-1.
3b	Surface hardness	C	1	1	T3b		T3b	The test shall be carried out on a surface which is smooth and even, free from oxide scale and foreign matter. Preparation shall be carried out in such a way that any alteration of the surface hardness is minimized. This shall be taken into account particularly in the case of low-depth indentations (in accordance with EN ISO 6508-1:2005, clause 6).

Table 10 – (continued)

1		2	3	4	5	6	7	(Supplement to Table 10, columns 6 and 7)	
No.	Requirements	Test unit ^a	Extent of testing	Number of products per test unit	Number of tests per product	Sampling and sample preparation (see in the supplement to this table, line T1 and line ...)	Test method to be applied	Line	Sampling and sample preparation
4	Mechanical properties of quenched and tempered products	8	C +D +T	1	1 tensile and 3 Charpy-V-notch impact tests	T4a	T4a	T4	Tensile test and impact tests
									The test pieces for tensile test, and where applicable, the Charpy-V-notch impact tests shall be taken as follows: — for bars and rod in accordance with EN 10083-1:2006, Figure 1; — for flat products in accordance with EN 10083-1:2006, Figures 2 and 3; — in the case of hammer and drop forgings (see note 2 in EN 10083-1:2006, Clause 1), the test pieces shall be taken from a position agreed at the time of ordering in such a way that their longitudinal axis lies in the direction of principal grain flow. The tensile test pieces shall be prepared in accordance with EN 10002-1, the impact test pieces in accordance with EN 10045-1.
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 9.									
^a The tests shall be carried out separately for each cast indicated by "C" – and for each heat treatment batch as indicated by "T". Products of different thicknesses may be grouped if the thicknesses lie in the same dimension range for mechanical properties and if the differences do not affect the properties. ^b If the product is continuously heat treated, one test piece shall be taken for each 25 t or part thereof, but at least one test piece shall be taken per cast.									

Table 11 — Heat treatment ^a

Steel designation ^b		Quenching ^{c,d}	Quenching ^e	Tempering ^f	End quench test
Name	Number	°C	agent	°C	°C
38Cr2	1.7003	830 to 870	Oil or water	540 to 680	850 ± 5
46Cr2	1.7006	820 to 860	Oil or water	540 to 680	850 ± 5
34Cr4	1.7033	830 to 870	Water or oil	540 to 680	850 ± 5
34CrS4	1.7037				
37Cr4	1.7034	825 to 865	Oil or water	540 to 680	850 ± 5
37CrS4	1.7038				
41Cr4	1.7035	820 to 860	Oil or water	540 to 680	850 ± 5
41CrS4	1.7039				
25CrMo4	1.7218	840 to 900	Water or oil	540 to 680	850 ± 5
25CrMoS4	1.7213				
34CrMo4	1.7220	830 to 890	Oil or water	540 to 680	850 ± 5
34CrMoS4	1.7226				
42CrMo4	1.7225	820 to 880	Oil or water	540 to 680	850 ± 5
42CrMoS4	1.7227				
50CrMo4	1.7228	820 to 870	Oil	540 to 680	850 ± 5
34CrNiMo6	1.6582	830 to 860	Oil or water	540 to 660	850 ± 5
30CrNiMo8	1.6580	830 to 860	Oil or water	540 to 660	850 ± 5
35NiCr6	1.5815	840 to 860	Oil or water	530 to 630	850 ± 5
36NiCrMo16	1.6773	865 to 885	Air, oil or water	550 to 650	850 ± 5
39NiCrMo3	1.6510	830 to 850	Oil or water	550 to 650	850 ± 5
30NiCrMo16-6	1.6747	840 to 860	Oil	540 to 630	850 ± 5
51CrV4	1.8159	820 to 870	Oil	540 to 680	850 ± 5
20MnB5	1.5530	880 to 920	Water	400 to 600	900 ± 5
30MnB5	1.5531	860 to 900	Water	400 to 600	880 ± 5
38MnB5	1.5532	840 to 880	Water or oil	400 to 600	850 ± 5
27MnCrB5-2	1.7182	880 to 920	Water or oil	400 to 600	900 ± 5
33MnCrB5-2	1.7185	860 to 900	Oil	400 to 600	880 ± 5
39MnCrB6-2	1.7189	840 to 880	Oil	400 to 600	850 ± 5

^a The conditions given in this table are for guidance. However, the temperatures specified for the end quench test are mandatory.

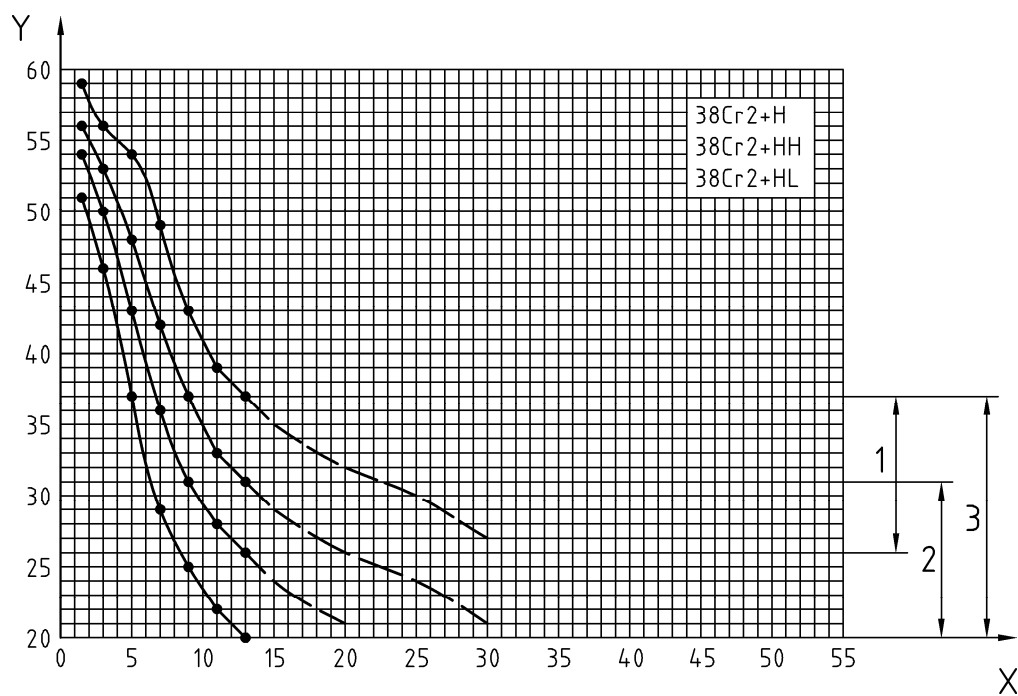
^b This table also applies for the various grades with specified hardenability (+H-, +HH- and +HL grades) covered in Tables 5 and 6.

^c The temperatures at the lower end of the range are generally applicable to hardening in water and those at the upper end for hardening in oil.

^d Austenitizing period: at least 30 min (guide value).

^e When choosing the quenching agent the influence of other parameters, such as shape, dimensions and quenching temperature on properties and crack susceptibility should be taken into account. Other quenching agents such as synthetic quenchants may also be used.

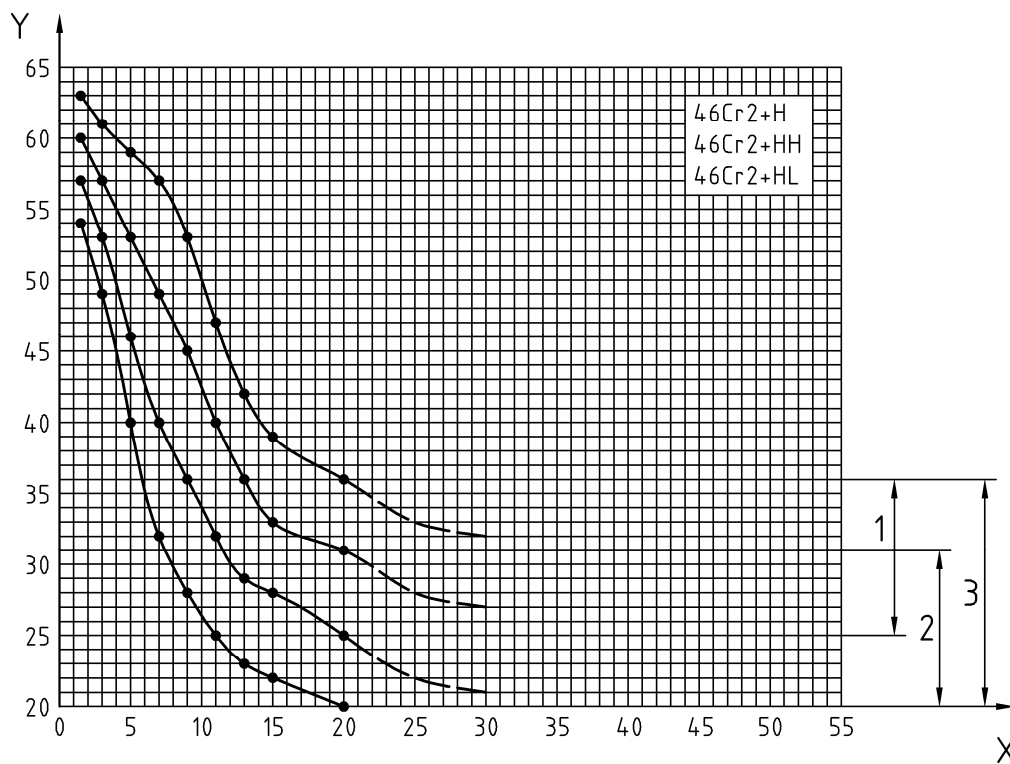
^f Tempering period: at least 60 min (guide value).



Key

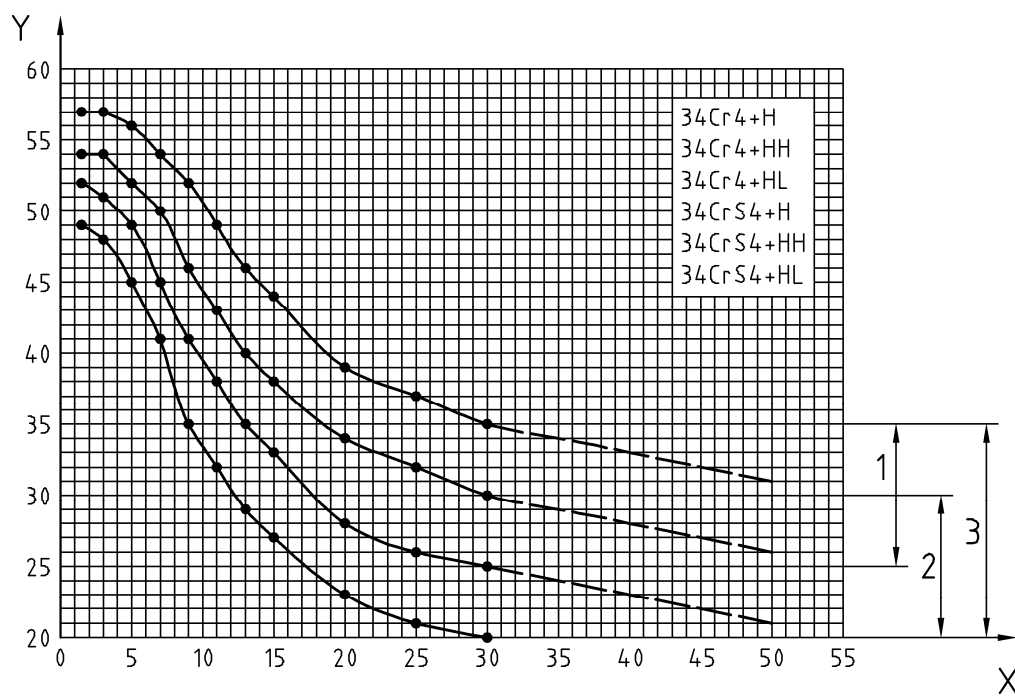
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1a — 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

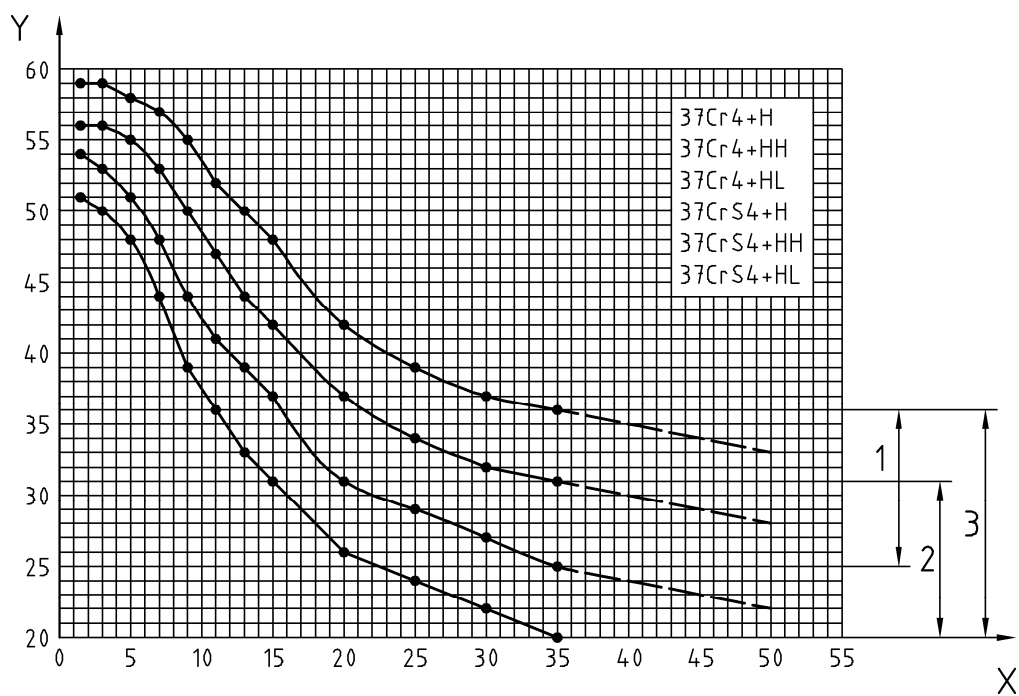
Figure 1b — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

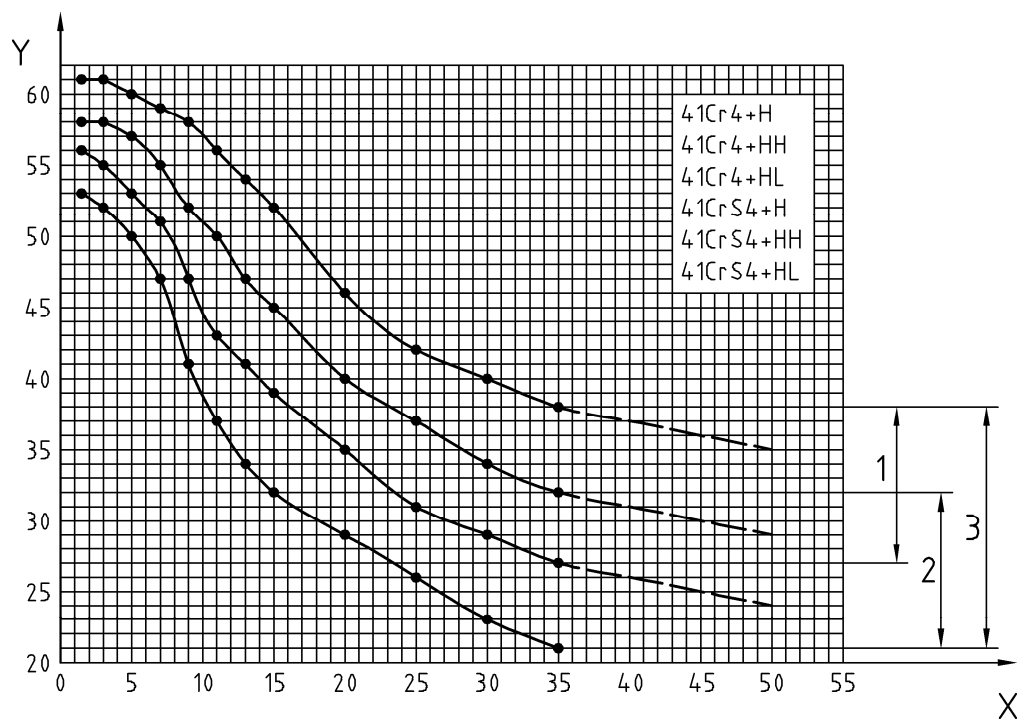
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1c — 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

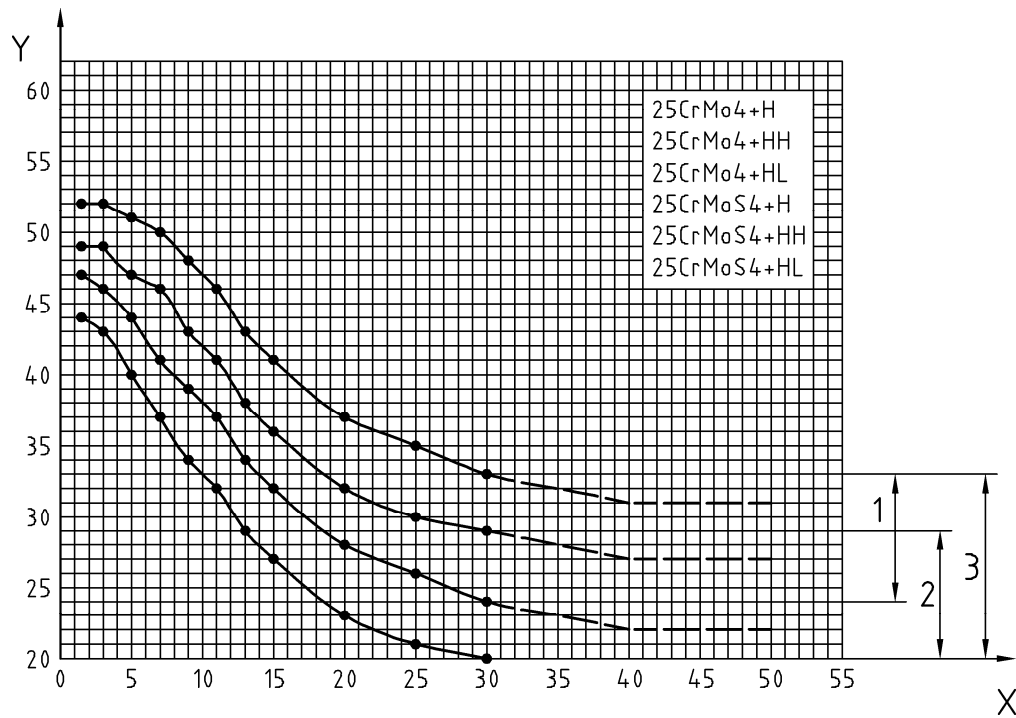
Figure 1d — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

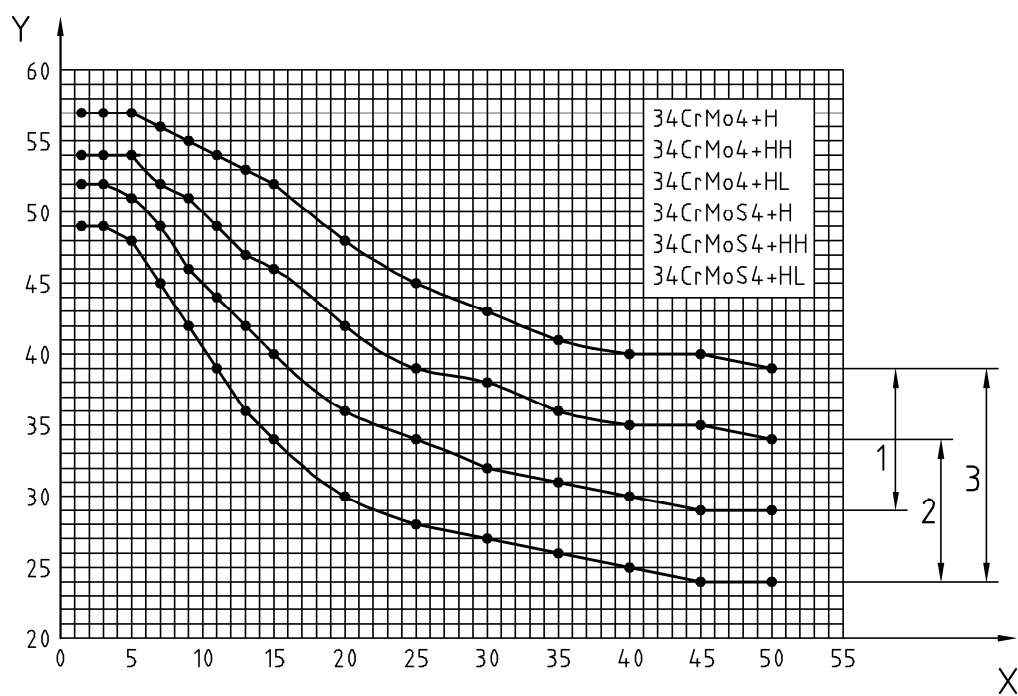
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1e — 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

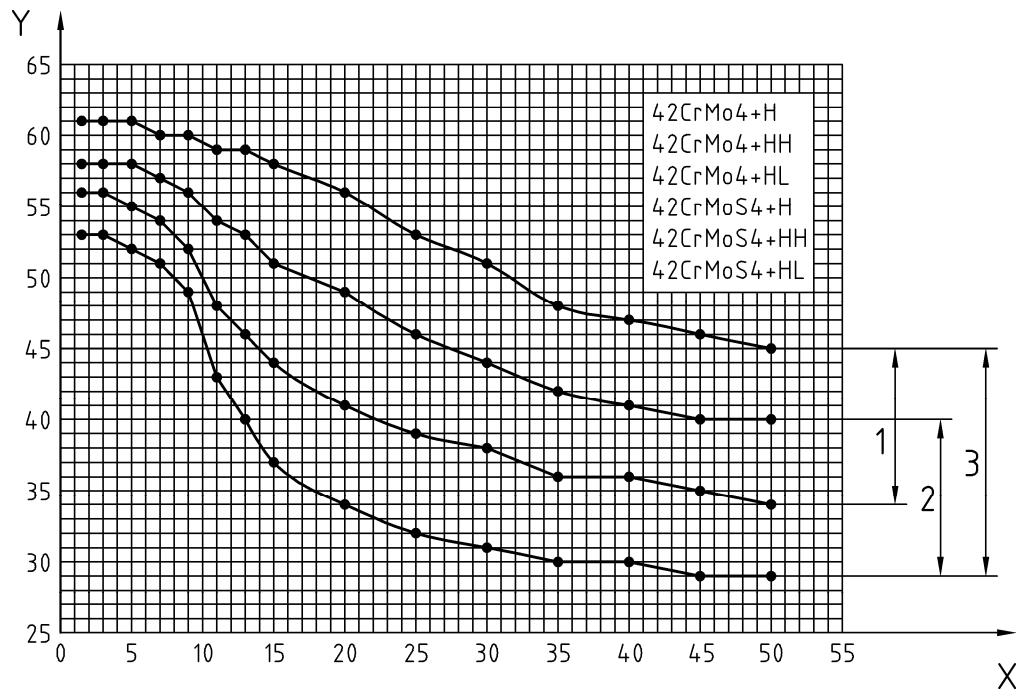
Figure 1f — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

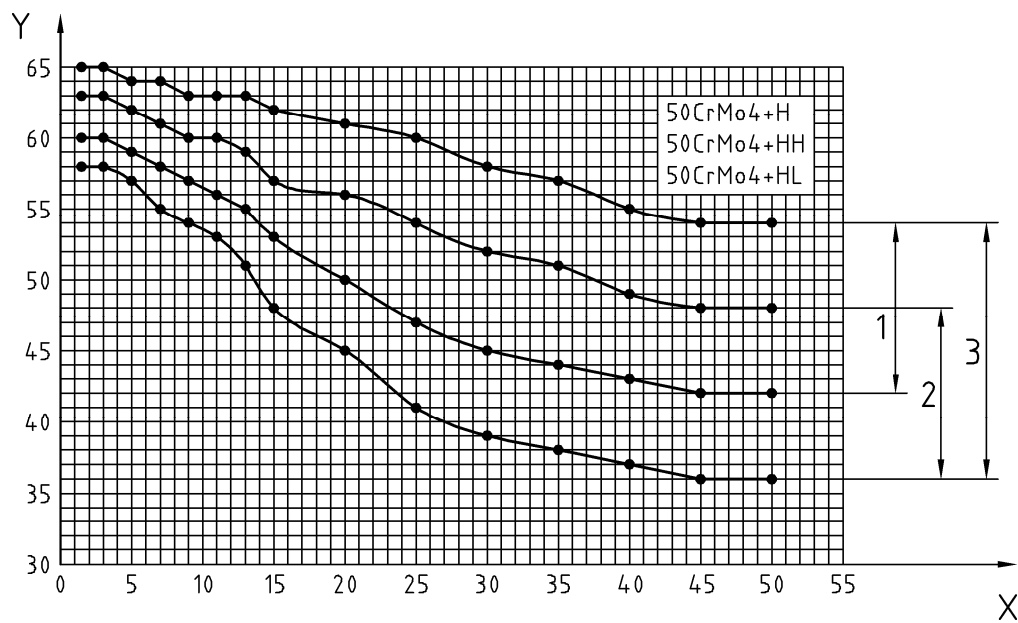
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1g — 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

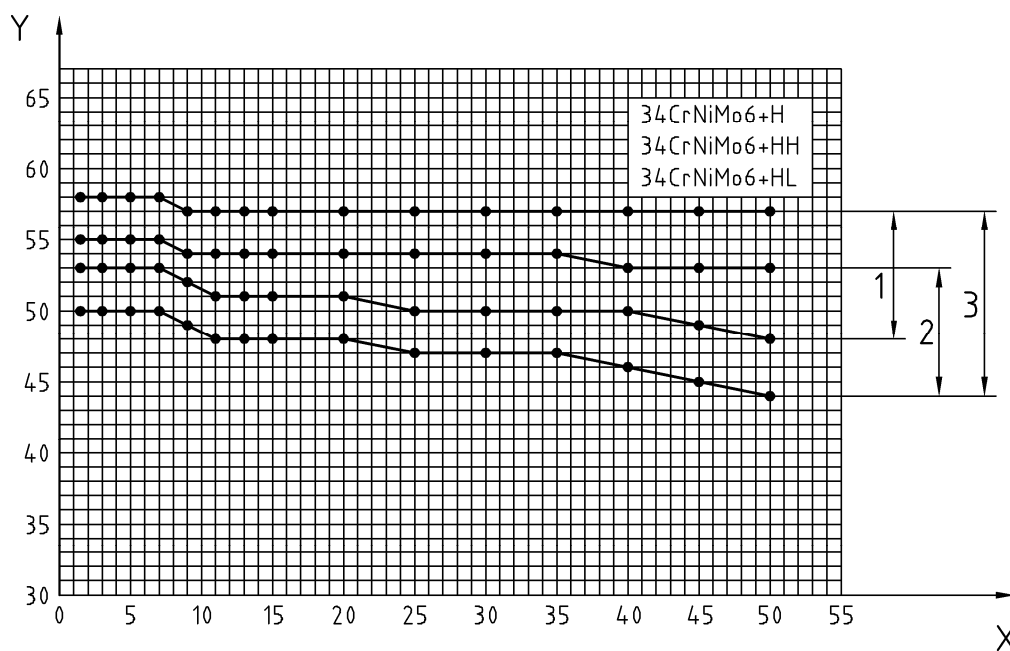
Figure 1h — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

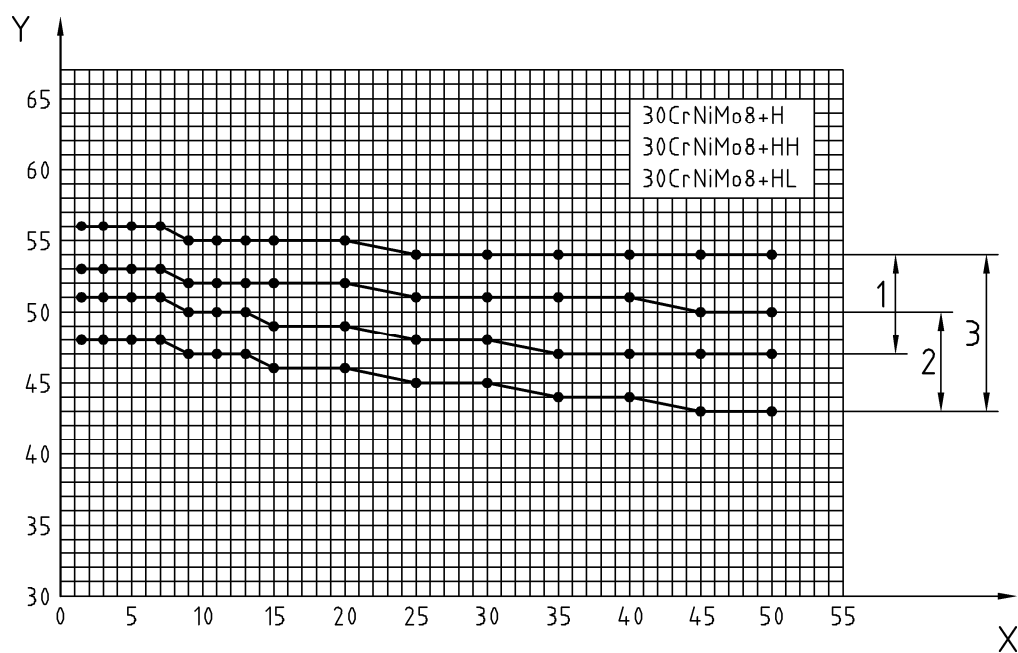
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1i — 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

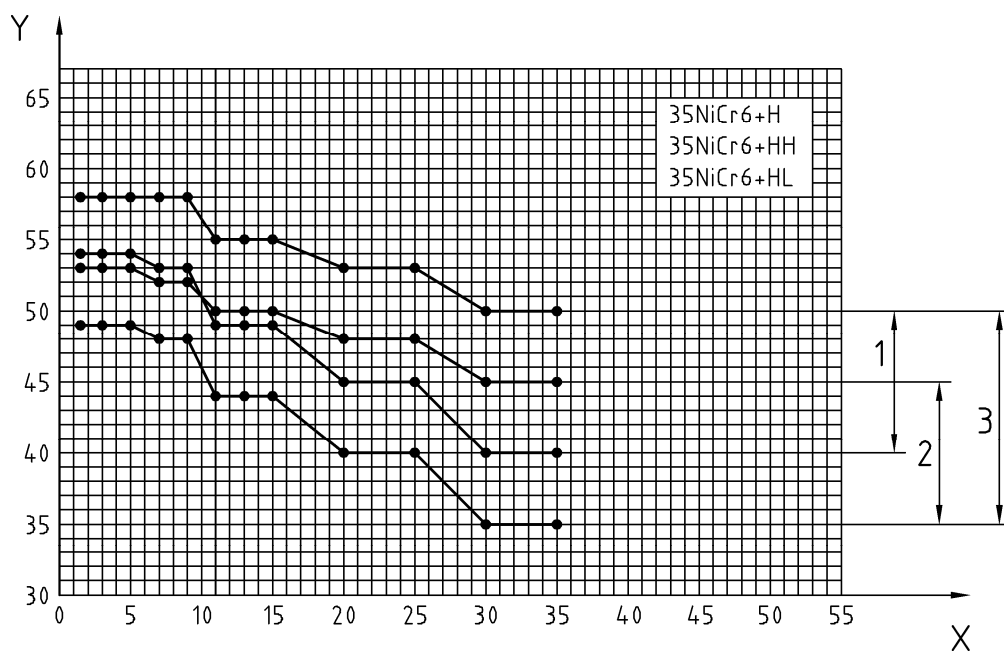
Figure 1j — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

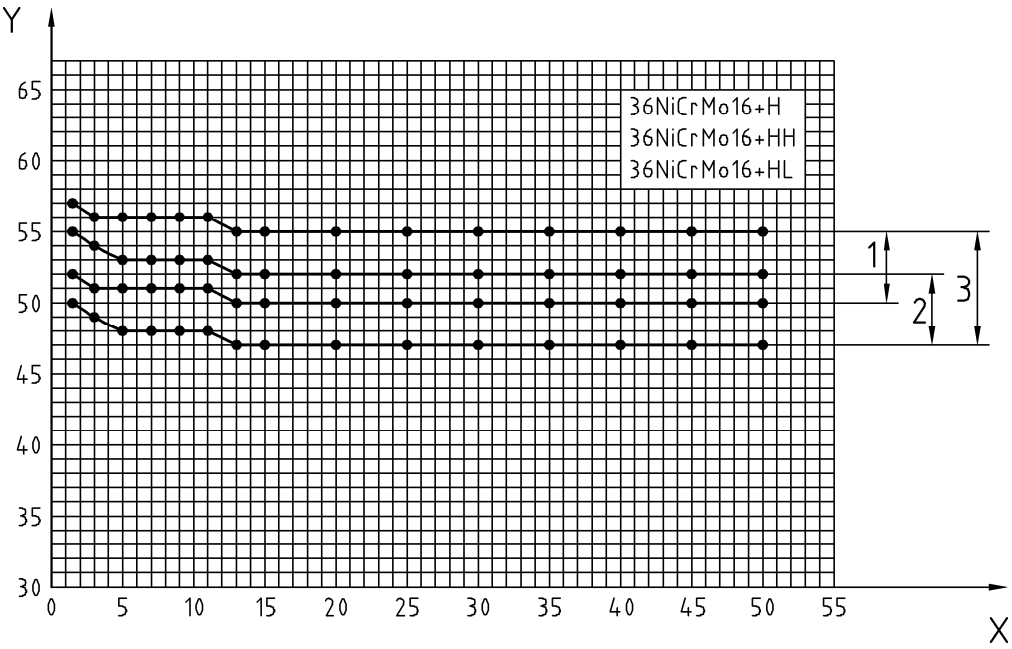
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1k — 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

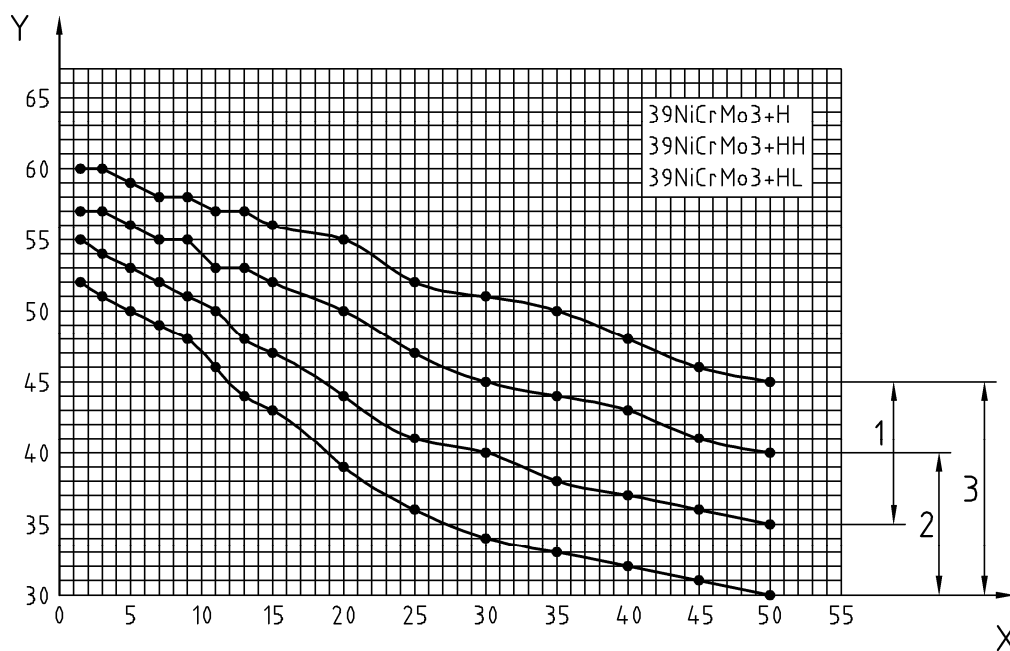
Figure 1I — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

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

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

**Key**

X Distance from quenched end of test piece, mm

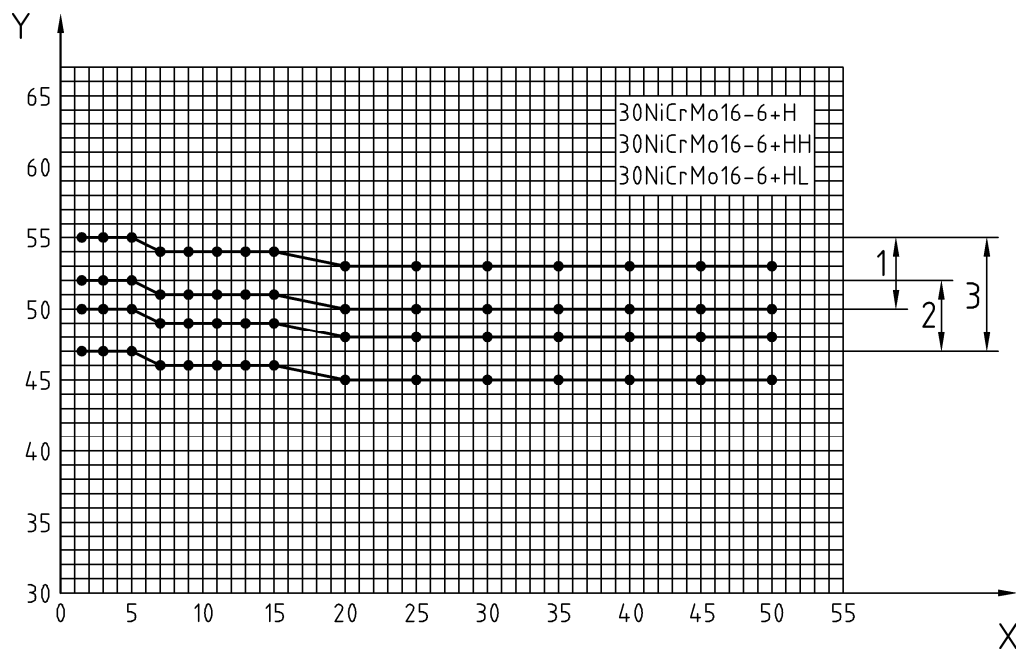
Y Hardness, HRC

1 HH-grade

2 HL-grade

3 H-grade

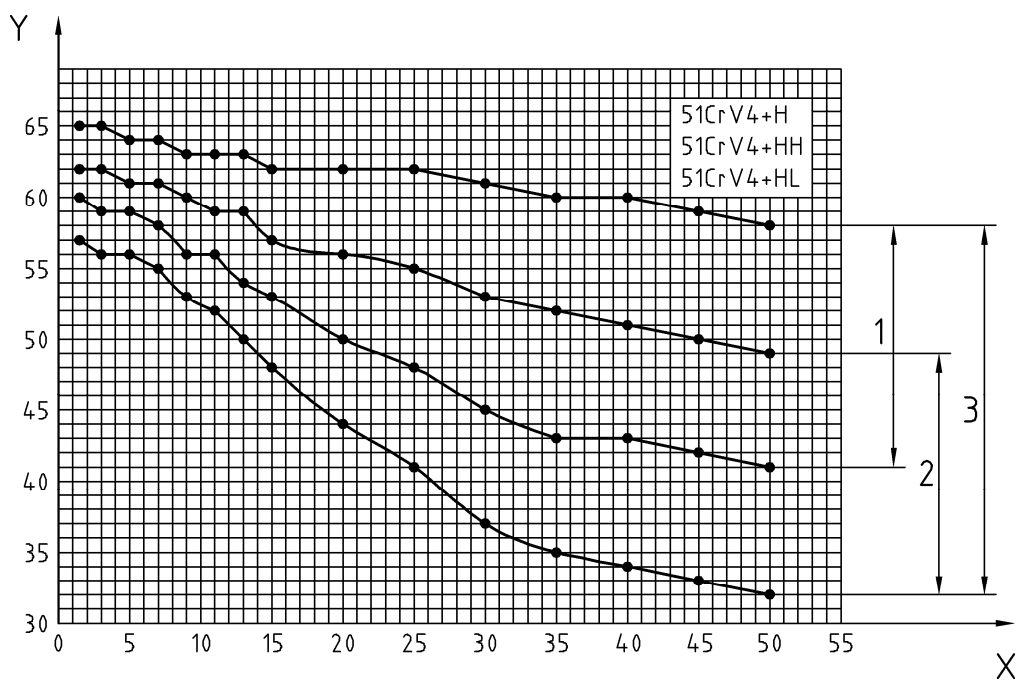
Figure 1n — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

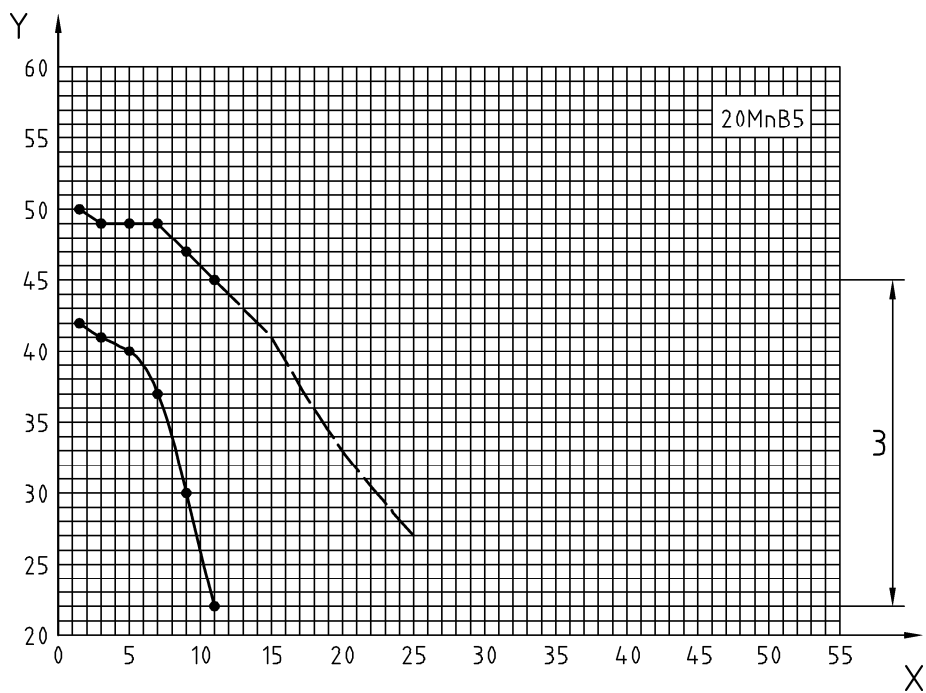
X Distance from quenched end of test piece, mm
Y Hardness, HRC
1 HH-grade
2 HL-grade
3 H-grade

Figure 1o — 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

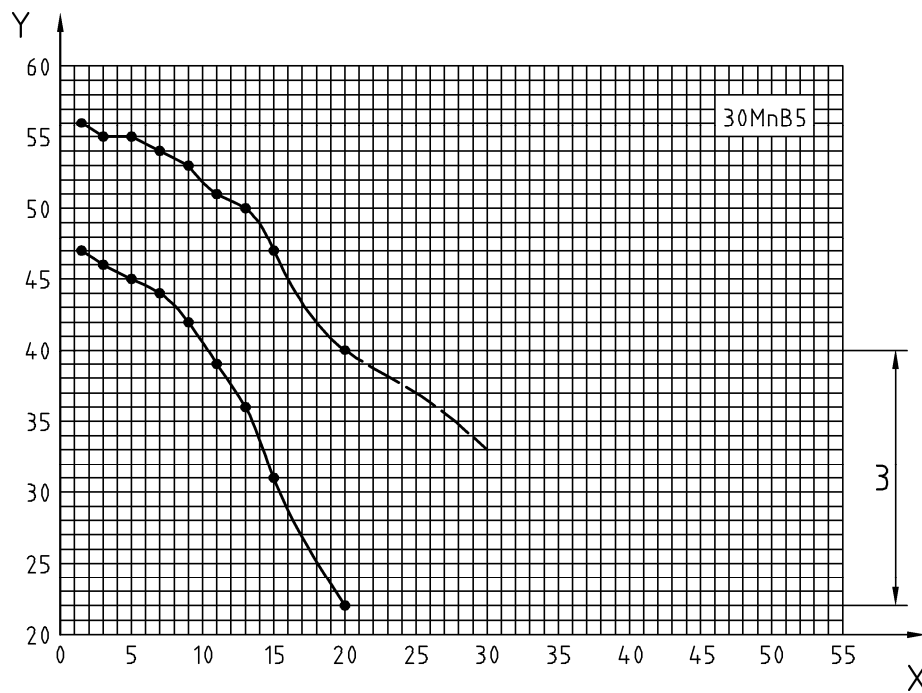
Figure 1p — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

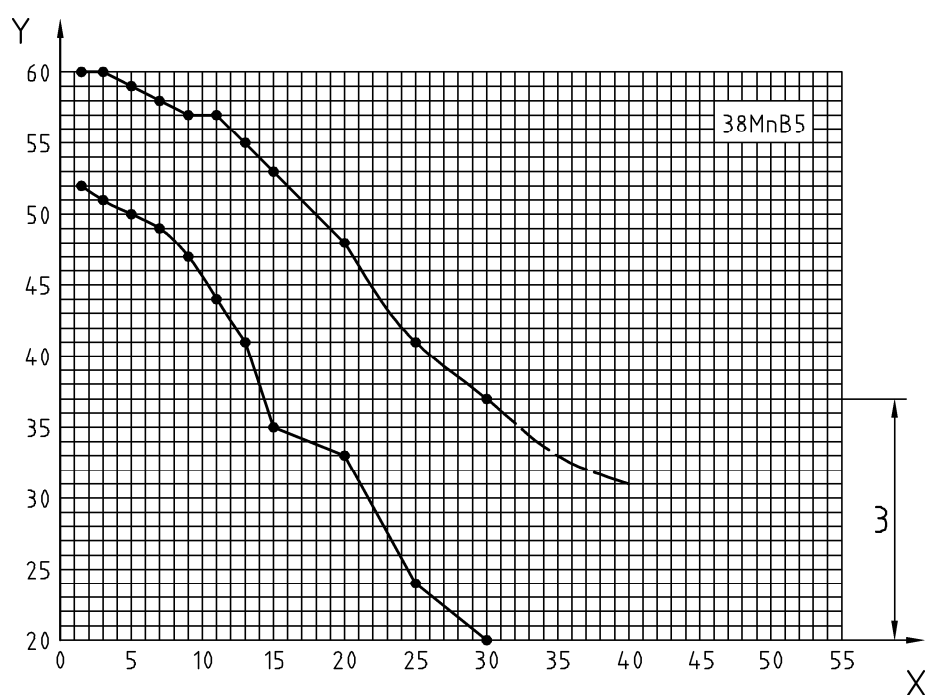
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1q — 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

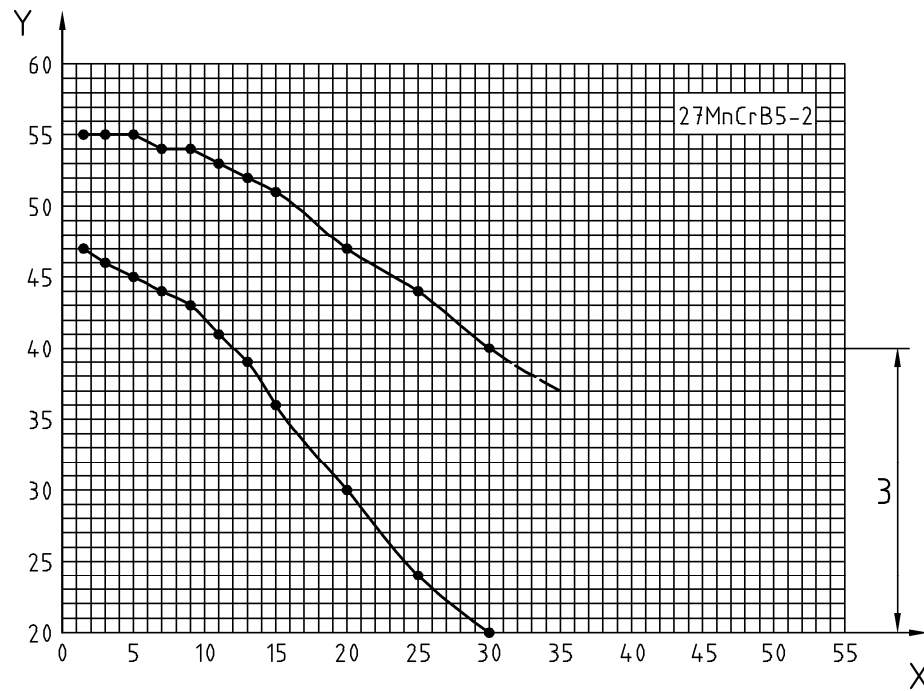
Figure 1r — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

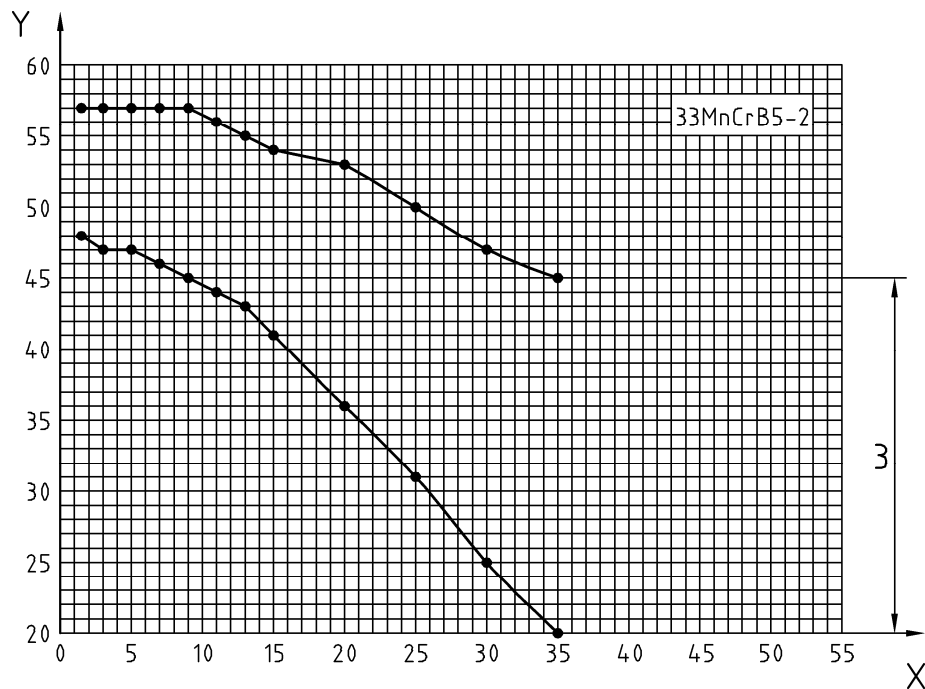
- X Distance from quenched end of test piece, mm
- Y Hardness, HRC
- 1 HH-grade
- 2 HL-grade
- 3 H-grade

Figure 1s — 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

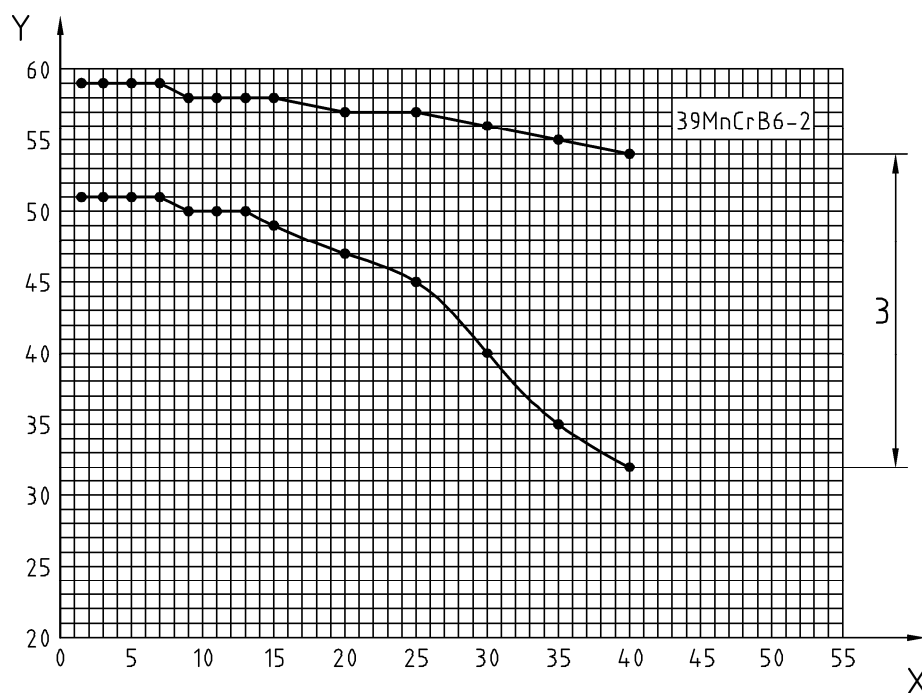
Figure 1t — Scatter bands for the Rockwell - C hardness in the end quench hardenability test



Key

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

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

Annex A **(normative)**

Options

NOTE 1 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 purchaser at the time of enquiry and order if necessary.

NOTE 2 The numbering of clauses is the same as in EN 10083-1:2006, annex B.

A.1 Mechanical properties of reference test pieces in the quenched and tempered condition

For deliveries in a condition other than quenched and tempered, the requirements for the mechanical properties in the quenched and tempered condition shall be verified on a reference test piece.

In the case of bars and rods, the sample to be quenched and tempered shall, unless otherwise agreed, have the cross-section of the product. In all other cases the dimensions and the manufacture of the sample shall be agreed at the time of enquiry and order, where appropriate, while taking into consideration the indications for the determination of the ruling section given in EN 10083-1:2006, Annex A. The samples shall be quenched and tempered in accordance with the conditions given in Table 11 or as agreed at the time of enquiry and order. The details of the heat treatment shall be given in the inspection document. The test pieces shall, unless otherwise agreed, be taken in accordance with EN 10083-1:2006, Figure 1 for bars and rods and in accordance with EN 10083-1:2006, Figure 3 for flat products.

A.2 Fine grain steel

This supplementary requirement concerns only the verification of the fine grain size.

When tested in accordance with EN ISO 643, the steel shall have an austenite grain size of 5 or finer. If specific testing is ordered, it shall also be agreed whether this grain size requirement is to be verified by determining the aluminium content or micrographically. In the first case, the aluminium content shall also be agreed.

In the second case, one test piece shall be inspected per cast for the determination of the austenitic grain size. Sampling and sample preparation shall be as specified in EN ISO 643.

Unless otherwise agreed at the time of enquiry and order, the quenched grain size shall be determined. Hardening shall be carried out under the following conditions for the purposes of determining the quenched grain size:

- for steels with a lower carbon content limit $< 0,35 \%$: $(880 \pm 10) ^\circ\text{C}$, 90 min/water;
- for steels with a lower carbon content limit $\geq 0,35 \%$: $(850 \pm 10) ^\circ\text{C}$, 90 min/water.

In cases of dispute, pretreatment at $1\ 150 ^\circ\text{C}$ for 30 min/air shall be carried out in order to produce a uniform starting condition.

A.3 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 EN 10083-1:2006, Annex E).

NOTE 1 The requirements for non metallic inclusion content apply in every case, however, verification requires a special agreement.

NOTE 2 For steels with a specified minimum sulphur content the agreements should only concern the oxides.

A.4 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.5 Product analysis

One product analysis shall be carried out per cast for elements for which values are specified for the cast analysis of the steel type concerned.

The conditions for sampling shall be in accordance with EN ISO 14284. In the case 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 CR 10261.

A.6 Special agreements for 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)

Comparison of steel grades specified in this European Standard and ISO 683-1:1987 and other steel grades previously standardized nationally

Table B.1 — Comparison of steel grades

EN 10083-3	Number		ISO 683-1:1987 ^a	Germany ^a		United Kingdom ^a	France ^a	Italy ^a	Sweden SS-steel	Spain ^a	
	Name	Number		Name	Number					Name	Number
	38Cr2	1.7003	-	38Cr2	1.7003	-	(38 C 2)	-	-	-	-
	46Cr2	1.7006	-	46Cr2	1.7006	-	-	-	-	-	-
	34Cr4	1.7033	34Cr4	34Cr4	1.7033	(530M32)	(32 C 4)	-	-	-	-
	34CrS4	1.7037	34CrS4	34CrS4	1.7037	-	(32 C 4 u)	-	-	-	-
	37Cr4	1.7034	37Cr4	37Cr4	1.7034	(530M36)	(38 C 4)	-	-	38Cr4	F1201
	37CrS4	1.7038	37CrS4	37CrS4	1.7038	-	(38 C 4 u)	-	-	38Cr41	F1206(1)
	41Cr4	1.7035	41Cr4	41Cr4	1.7035	(530M40)	42 C 4	(41Cr4)	-	42Cr4	F1202
	41CrS4	1.7039	41CrS4	41CrS4	1.7039	-	42 C 4 u	(41Cr4)	-	42Cr41	F1207(1)
	25CrMo4	1.7218	25CrMo4	25CrMo4	1.7218	(708M25)	25 CD 4	(25CrMo4)	2245	-	-
	25CrMoS4	1.7213	25CrMoS4	25CrMoS4	1.7213	-	25 CD 4 u	(25CrMo4)	2225	-	-
	34CrMo4	1.7220	34CrMo4	34CrMo4	1.7220	(708M32)	(34 CD 4)	(35CrMo4)	2234	-	-
	34CrMoS4	1.7226	34CrMoS4	34CrMoS4	1.7226	-	(34 CD 4 u)	(35CrMo4)	-	-	-
	42CrMo4	1.7225	42CrMo4	42CrMo4	1.7225	(708M40)	42 CD 4	(42CrMo4)	2244	40CrMo4	F1252
	42CrMoS4	1.7227	42CrMoS4	42CrMoS4	1.7227	-	42 CD 4 u	(42CrMo4)	-	40CrMo41	F1257(1)
	50CrMo4	1.7228	50CrMo4	50CrMo4	1.7228	(708M50)	-	-	-	-	-
	34CrNiMo6	1.6582	(36CrNiMo6)	(34CrNiMo6)	1.6582	(817M40)	-	-	2541	-	-
	30CrNiMo8	1.6580	(31CrNiMo8)	30CrNiMo8	1.6580	[823M30]	30 CND 8	-	-	-	-
	35NiCr6	1.5815	-	35NiCr6	-	-	-	-	-	-	-
	36NiCrMo16	1.6773	-	-	-	-	35 NCD 16	-	-	-	-
	39NiCrMo3	1.6510	-	-	-	-	-	(39NiCrMo3)	-	-	-
	30NiCrMo16-6	1.6747	-	30NiCrMo16-6	1.6747	[835M30]	-	-	-	-	-
	51CrV4	1.8159	(51CrV4)	50CrV4	1.8159	[735A50]	(50CV 4)	(50CrV4)	-	51CrV4	F1430

^a If a steel grade is given in round brackets, this means that the chemical composition differs only slightly from EN 10083-3. If it is given in square brackets, this means that greater differences exist in the chemical composition compared with EN 10083-3. If there are no brackets around the steel grade, this means that there are practically no differences in the chemical composition compared with EN 10083-3.

Annex C

(informative)

Reference values for the maximum diameter at a certain core hardness of steels with boron

Table C.1 contains reference data for the maximum diameter at certain core hardness after hardening in oil or water.

Table C.1 — Reference values for the maximum diameter at a certain core hardness of steels with boron

Steel name	Hardening temperature °C	Core hardness ^a HRC	Approximate maximum diameter mm	
			Water	Oil
20MnB5	900	34	32	25
30MnB5	880	40	38	30
38MnB5	850	45	40	32
27MnCrB5-2	900	38	52	43
33MnCrB5-2	880	42	55	45
39MnCrB6-2	850	45	95	80
^a For 80 % martensite.				

Bibliography

- [1] EN 10021, *General technical delivery requirements for steel and iron products*

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