

Hot rolled steels for quenched and tempered springs — Technical delivery conditions

The European Standard EN 10089:2002 has the status of a
British Standard

ICS 77.140.25

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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Hot-rolled steels for quenched and tempered springs - Technical delivery conditions

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Conditions techniques de livraison

Warmgewalzte Stähle für vergütbare Federn - Technische
Lieferbedingungen

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Foreword

This document (EN 10089:2002) 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of an identical text or by endorsement, at the latest by June 2003, and conflicting national standards shall be withdrawn at the latest by June 2003.

In this European Standard annex A is normative and annexes B, C and D are informative.

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

1 Scope

1.1 This European Standard specifies the technical delivery requirements for round and flat bars, ribbed and grooved bars and rod manufactured from the alloy steels listed in Table 3, intended for hot-formed and subsequently heat-treated springs or cold-formed and subsequently heat-treated springs. The products are 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.

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.

2 Normative references

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

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

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

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

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

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

EN 10079, *Definition of steel products.*

EN 10204, *Metallic products — Types of inspection documents.*

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

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 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:1999).*

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 6508-1:1999).*

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

CR 10260, *Designation systems for steels — Additional symbols.*

CR 10261, *ECISS Information Circular 11 - Iron and steel — Review of available methods of chemical analysis.*

EURONORM 103¹⁾, *Microscopic determination of the ferritic or austenitic grain size of steels.*

EURONORM 104¹⁾, *Determination of the depth of decarburization of non-alloy and low alloy structural steels.*

3 Terms and definitions

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

3.1

spring steels

materials which are, because of their properties in the quenched and tempered condition, particularly suitable for the manufacture of spring like components of all kinds. The resilience of the steels depends on their elastic deformability, which enables them to sustain loading within a given range without exhibiting any permanent deformation when the load is removed. The properties required of the steels for springs are obtained by higher carbon contents and alloying constituents such as silicon, manganese, chromium, molybdenum and vanadium, and also by heat-treatment, i. e. hardening with subsequent tempering.

4 Classification and designation

4.1 Classification

All steels covered by this European Standard are classified as alloy special steels according to EN 10020.

4.2 Designation

4.2.1 Steel names

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

4.2.2 Steel numbers

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

¹⁾ It may be agreed at the time of ordering, until these EURONORMS have been adopted as European Standard, that these EURONORMS or the corresponding national standards should be applied.

5 Information to be supplied by the purchaser

5.1 Mandatory information

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

- a) the quantity to be delivered;
- b) the designation of the product form (e. g. round or square);
- c) the number of the dimensional standard;
- d) the dimensions and tolerances on dimensions and shape and, if applicable, letters denoting relevant special tolerances;
- e) the number of this European Standard (EN 10089);
- f) steel name or steel number (see 4.2);
- g) if appropriate, the symbol for the heat treatment condition at delivery (see 6.3.1, 6.3.2 and Table 1);
- h) if appropriate, the symbol for the surface condition at delivery (see 6.3.3 and Table 2);
- i) if required, the type of inspection document in accordance with EN 10204 (see 8.1).

EXAMPLE 20 rounds prEN 10060 - 20 × 8000
 EN 10089 - 51CrV4+A
 EN 10204 - 3.1.B

or

20 rounds prEN 10060 - 20 × 8000
EN 10089 - 1.8159+A
EN 10204 - 3.1.B

5.2 Options

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

- a) any requirement concerning grain size (see 7.3 and 8.2.3);
- b) any requirement concerning non-metallic inclusion content (see 7.3.2 and clause A.1);
- c) any requirement for internal soundness (see 7.4 and clause A.2);
- d) any requirement relating to surface quality (see 7.5.2);
- e) any requirement relating to removal of surface defects (see 7.5.4);
- f) any requirement concerning special marking of the products (see clauses 9 and A.4);
- g) any verification of the product analysis (see Table 10 and clause A.3).

6 Manufacturing process

6.1 General

The manufacturing process of the steel and of the products is left to the discretion of the manufacturer with the restrictions given by the requirements in 6.2 and 6.3.

6.2 Deoxidation

All steels shall be fully killed.

6.3 Heat-treatment and surface condition at delivery

6.3.1 Normal condition at delivery

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

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 in one of the particular surface conditions given in Table 2, lines 3 to 6.

6.3.4 Cast separation

The steels shall be delivered separated by casts.

7 Requirements

7.1 Chemical composition, hardness and hardenability

7.1.1 Table 1 gives a survey of combinations of usual heat-treatment conditions at delivery, product forms and requirements according to Tables 3 to 8 (chemical composition, maximum dimensions for a minimum core hardness, hardenability, maximum hardness).

7.1.2 Where the steel is not ordered according to core hardness or restricted hardenability requirements, i. e. where the steel type designations of Table 3, Table 6 or Table 7 and not the designations given in Table 5 or Table 8 are applied, the requirements for chemical composition, hardenability and maximum hardness cited in Table 1, (column 5) apply as appropriate, for the particular heat-treatment condition.

7.1.3 Where the steel is, by using the designations given in Table 5, ordered according to core hardness requirements, the values of core hardenability given in Table 5 or Table B.1 apply, in addition to the requirements cited in Table 1, columns 5 (1) and 5 (2). In this case, the values of end-quench hardenability given in Table 7 or Table 8 are for guidance purposes only.

NOTE The maximum dimensions given in Table 5 correspond to the restricted hardenability scatterband according to Table 8. For smaller sizes (Table B.1) the normal hardenability scatterband according to Table 7 can be sufficient.

7.1.4 Where the steel is, by using the designations given in Table 8, ordered according to restricted hardenability requirements, the values of restricted hardenability given in Table 8 apply, in addition to the requirements cited in Table 1, columns 5 (1) and 5 (2).

7.2 Shearability

Under suitable shearing conditions (avoiding local stress peaks, preheating, application of blades with a profile adapted to that of the product, etc.) all steels are normally shearable in the as-rolled condition (+AR), except in abnormal circumstances where it may be necessary to supply in conditions +S or +A (see Table 6).

7.3 Structure

7.3.1 The steel, when tested in accordance with one of the methods described in EURONORM 103 shall show an austenitic grain size of 6 or finer.

7.3.2 For the content of non-metallic inclusions, see A.1.

7.4 Internal soundness

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

7.5 Surface quality and decarburisation

7.5.1 All products shall have a workmanlike finish.

7.5.2 At the time of enquiry and order, agreements may be made with regard to the required surface quality.

In the case of hot-rolled round bars and rods, such agreements shall be based on the requirements of EN 10221.

7.5.3 The values for the admissible partial surface decarburisation given in Table 9 apply for the as rolled condition (+AR), for the treated to improve shearability condition (+S), for the soft annealed condition (+A) and for the annealed to achieve spheroidization of the carbides condition (+AC) and for the testing conditions given in 8.2.2.2.

7.5.4 Removal of surface discontinuities by welding is not permitted.

If surface discontinuities are to be removed by other methods, the kind and permissible depth for removal of surface discontinuities should, where appropriate, 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 C).

8 Inspection and testing

8.1 Types and contents of inspection documents

8.1.1 For each delivery, the issue of any inspection document according to EN 10204 may be agreed upon at the time of enquiry and order.

8.1.2 If, in accordance with the agreements made at the time of enquiry and order, a test report is to be provided, this shall cover:

- a) the statement that the material complies with the requirements of the order;
- b) the results of the cast analysis for all elements specified for the type of steel supplied.

8.1.3 If, in accordance with the agreements in the order, an inspection certificate 3.1.A, 3.1.B or 3.1.C or an inspection report 3.2 (see EN 10204) is to be provided, the specific inspections and tests described in 8.2 shall be carried out and their results shall be certified in the document.

In addition the document shall cover

- a) for all elements specified for the steel type concerned, the results of the cast analysis given by the manufacturer;
- b) the result of all inspections and tests ordered by supplementary requirements (according to Annex A);
- c) the symbol letters or numbers relating the inspection documents, the test pieces and products to each other.

8.2 Specific inspection and testing

8.2.1 Verification of the hardenability and hardness

8.2.1.1 For steels ordered with the designation given in Tables 7 or 8, unless otherwise agreed, only the end-quench hardenability requirements according to Tables 7 or 8 shall be verified.

For steels ordered without end-quench hardenability requirements but with core hardness requirements, i. e. with the symbol +CH in the designation, the hardness requirements given for the relevant heat-treatment condition in Table 1, column 5 (2) and the hardness requirements for core hardenability according to Table 5 shall be verified.

8.2.1.2 The amount of testing, the sampling conditions and the test methods to be applied for the verification of the requirements shall be in accordance with the specifications in Table 10.

8.2.2 Testing of the surface quality and decarburization

8.2.2.1 For round bars and rods, the verification of the surface quality shall be in accordance with EN 10221, unless otherwise agreed. For flat bars, the details of verification are to be agreed upon at the time of enquiry and order.

8.2.2.2 For testing the depth of decarburisation, the amount of testing is, unless otherwise agreed, left to the manufacturer. The test is carried out by using the micrographic method specified in EURONORM 104 and under the following conditions.

- For round products, the measurement starts at the deepest uniformly decarburised zone, then three further measurements are made at right angles. The average of these four measurements is then taken.
- For flat products, the measurement is carried out on the inner third of the product and is started at the deepest uniformly decarburised zone, followed by a measurement on the opposite side. The average of these two measurements is then taken.
- Surface discontinuities are excluded from decarburisation measurements.

8.2.3 Verification of grain size

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

8.2.4 Visual and dimensional inspection

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

8.2.5 Retests

For retests, EN 10021 shall apply.

9 Marking

The manufacturer shall mark the products or the bundles or boxes containing the products in a suitable way, so that the identification of the cast, the steel type and the origin of the delivery is possible (see A.4).

Table 1 — Combinations of usual heat-treatment conditions at delivery, product forms and requirements according to Tables 3 to 8

1	2		3	4	5			6			7									
1	Heat treatment condition at delivery	Symbol	Applicable for		Applicable requirements															
			bars (rounds and flats) and ribbed and grooved bars	rod	Unless otherwise agreed			If the steel is ordered with the designation given in Table 8			If the steel is ordered with the designation given in Table 5									
					1	2		3	1	2	3	1	2	3						
2	As rolled	+AR	X	X	Chemical composition according to Tables 3 and 4	—		Hardenability values according to Table 7	As in columns 5 (1) and 5 (2)			Restricted hardenability values according to Table 8			As in columns 5 (1) and 5 (2)			Maximum diameter or thickness for core hardness according to Table 5		
3	Treated to improve shearability	+S	X	—		Maximum Brinell hardness according to Table 6	Column +S													
4	Soft annealed	+A	X	X		Column +A														
5	Annealed to achieve spheroidization of the carbides	+AC	X	X		Column +AC														
6	Others	Other treatment conditions may be agreed upon at the time of enquiry and order.																		

Table 2 — Surface condition at delivery

1	2	3	4	5	6		
1	Surface condition at delivery		Symbol	In general applicable for			
				Bars	Rod		
2	Unless otherwise agreed		As rolled (+AR)	None or +AR	×	×	
3	Particular conditions supplied by agreement		+AR	+ PI	×	×	
4			+ pickled				
5			+AR	+ BC	×	×	
6			+ blast cleaned				
		+ AR + surface removal ^a	—	×	×		
		Others					

^a The type of surface removal may be agreed upon, for example by reference to the relevant dimensional standard.

Table 3 — Types of steel and specified chemical composition (applicable to cast analysis)

Designation		Mass fraction in % a b										
Name	Number	C	Si	Mn	P max.	S max.	Cr	Ni	Mo	V	Cu + Sn	
38Si7	1.5023	0,35 to 0,42	1,50 to 1,80	0,50 to 0,80	0,025	0,025						
46Si7	1.5024	0,42 to 0,50	1,50 to 2,00	0,50 to 0,80	0,025	0,025						
56Si7	1.5026	0,52 to 0,60	1,60 to 2,00	0,60 to 0,90	0,025	0,025						
55Cr3	1.7176	0,52 to 0,59	max. 0,40	0,70 to 1,00	0,025	0,025	0,70 to 1,00					
60Cr3	1.7177	0,55 to 0,65	max. 0,40	0,70 to 1,00	0,025	0,025	0,60 to 0,90					
54SiCr6	1.7102	0,51 to 0,59	1,20 to 1,60	0,50 to 0,80	0,025	0,025	0,50 to 0,80					
56SiCr7	1.7106	0,52 to 0,60	1,60 to 2,00	0,70 to 1,00	0,025	0,025	0,20 to 0,45					
61SiCr7	1.7108	0,57 to 0,65	1,60 to 2,00	0,70 to 1,00	0,025	0,025	0,20 to 0,45					
51CrV4	1.8159	0,47 to 0,55	max. 0,40	0,70 to 1,10	0,025	0,025	0,90 to 1,20			0,10 to 0,25		
45SiCrV6-2	1.8151	0,40 to 0,50	1,30 to 1,70	0,60 to 0,90	0,025	0,025	0,40 to 0,80			0,10 to 0,20		Cu+10Sn ± 0,60
54SiCrV6	1.8152	0,51 to 0,59	1,20 to 1,60	0,50 to 0,80	0,025	0,025	0,50 to 0,80			0,10 to 0,20		
60SiCrV7	1.8153	0,56 to 0,64	1,50 to 2,00	0,70 to 1,00	0,025	0,025	0,20 to 0,40			0,10 to 0,20		
46SiCrMo6	1.8062	0,42 to 0,50	1,30 to 1,70	0,50 to 0,80	0,025	0,025	0,50 to 0,80		0,20 to 0,30			
50SiCrMo6	1.8063	0,46 to 0,54	1,40 to 1,80	0,70 to 1,00	0,025	0,025	0,80 to 1,10		0,20 to 0,35			
52SiCrNi5	1.7117	0,49 to 0,56	1,20 to 1,50	0,70 to 1,00	0,025	0,025	0,70 to 1,00	0,50 to 0,70				
52CrMoV4	1.7701	0,48 to 0,56	max. 0,40	0,70 to 1,10	0,025	0,025	0,90 to 1,20		0,15 to 0,30	0,10 to 0,20		
60CrMo3-1	1.7239	0,56 to 0,64	max. 0,40	0,70 to 1,00	0,025	0,025	0,70 to 1,00		0,06 to 0,15			
60CrMo3-2	1.7240	0,56 to 0,64	max. 0,40	0,70 to 1,00	0,025	0,025	0,70 to 1,00		0,15 to 0,25			
60CrMo3-3	1.7241	0,56 to 0,64	max. 0,40	0,70 to 1,00	0,025	0,025	0,70 to 1,00		0,25 to 0,35			

a Elements which are not mentioned 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, from scrap or other material used during manufacture, of elements which could affect the hardenability, mechanical properties and application.

b In the case of the grades with specified hardenability requirements (see Tables 7 and 8), except for phosphorus and sulphur, insignificant deviations from the limits for cast analysis are permissible. These deviations shall, however, not exceed ± 0,01% (by mass) in the case of carbon, and the values according to Table 4 in all other cases.

Table 4 — Permissible deviations between specified analysis and product analysis

Element	Permissible maximum content according to cast analysis as a mass fraction in %	Limit deviation ^a as a mass fraction in %
C	≤ 0,55	± 0,02
	> 0,55 ≤ 0,65	± 0,03
Si	≤ 0,40	± 0,03
	> 0,40 ≤ 2,00	± 0,05
Mn	≤ 1,00	± 0,04
	> 1,00 ≤ 1,10	± 0,05
P	≤ 0,025	+ 0,005
S	≤ 0,025	+ 0,005
Cr	≤ 1,20	± 0,05
Mo	≤ 0,30	± 0,03
	> 0,30 ≤ 0,35	± 0,04
Ni	≤ 0,70	± 0,05
V	≤ 0,20	± 0,02

^a “±” 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.

Table 5 — Maximum dimensions for rounds and flats based on the upper 2/3 hardenability scatterband^a

Steel designation		C % by mass	Hardness HRC at		Distance from the quenched end A, mm		Maximum dimensions for oil quenched rounds D _{max} , mm content of martensite at the core		Maximum dimensions for oil quenched flats r _{max} , mm content of martensite at the core		
Steel name	Steel number		Symbol	min.	80 % martensite H ₈₀	90 % martensite H ₉₀	80 % martensite A	90 % martensite A	80 %	90 %	80 %
38Si7	1.5023	+CH	0,35	44	48	4,5	3,5	9	7	7	5
46Si7	1.5024	+CH	0,42	48	51	4	3,2	8	6	6	4
56Si7	1.5026	+CH	0,52	52	56	5,3	3,5	11	7	8	5
55Cr3	1.7126	+CH	0,52	52	56	11,5	9	28	21	20	15
60Cr3	1.7177	+CH	0,55	53	57	16,5	13	43	33	31	23
54SiCr6	1.7102	+CH	0,51	52	55	8,5	7	20	16	14	11
56SiCr7	1.7106	+CH	0,52	52	56	8	6	19	13	13	9
61SiCr7	1.7108	+CH	0,57	54	57	9	7,5	21	17	15	12
51CrV4	1.8159	+CH	0,47	50	54	20	13	54	33	39	23
45SiCrV6-2	1.8151	+CH	0,40	47	50	11	9	27	21	19	15
54SiCrV6	1.8152	+CH	0,51	52	55	8	6,5	19	14	13	10
60SiCrV7	1.8153	+CH	0,56	53	57	9,5	7	23	16	16	11
46SiCrMo6	1.8062	+CH	0,42	48	51	18,2	13	49	33	35	23
50SiCrMo6	1.8063	+CH	0,46	49	53	45	30	> 100	89	> 100	63
52SiCrNi5	1.7117	+CH	0,49	51	54	20	15	54	39	39	28
52CrMoV4	1.7701	+CH	0,48	50	54		20	> 100	54	> 100	39
60CrMo3-1	1.7239	+CH	0,56	53	57	22	15	61	39	44	28
60CrMo3-2	1.7240	+CH	0,56	53	57	33,2	25	> 100	71	72	51
60CrMo3-3	1.7241	+CH	0,56	53	57		40	> 100	> 100	> 100	91

^a For the hardening test temperature (Jominy test), see Table 8.

Table 6 — Maximum hardness in different heat-treatment conditions

Designation		Maximum Brinell hardness in the heat-treatment condition		
Name	Number	treated to improve shearability +S	soft annealed +A	annealed to achieve spheroidization of the carbides +AC
38Si7	1.5023	280	217	200
46Si7	1.5024	280	248	230
56Si7	1.5026	280	248	230
55Cr3	1.7176	280	248	230
60Cr3	1.7177	280	248	230
54SiCr6	1.7102	280	248	230
56SiCr7	1.7106	280	248	230
61SiCr7	1.7108	280	248	230
51CrV4	1.8159	280	248	230
45SiCrV6-2	1.8151	280	248	230
54SiCrV6	1.8152	280	248	230
60SiCrV7	1.8153	280	248	230
46SiCrMo6	1.8062	280	248	230
50SiCrMo6	1.8063	280	248	230
52SiCrNi5	1.7117	280	248	230
52CrMoV4	1.7701	280	248	230
60CrMo3-1	1.7239	280	248	230
60CrMo3-2	1.7240	280	248	230
60CrMo3-3	1.7241	280	248	230

Table 7 — Hardness limits for steel types with specified hardenability (+H, see 7.1.2)

Designation		Symbol	Hardening temperature for end-quench test °C	Limits of range ^a	Hardness HRC at a distance, in millimetres, from quenched end of test piece of														
Name	Number				1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
38Si7	1.5023	+H	880 ± 5	max.	61	58	51	44	40	37	34	32	29	27	26	25	25	24	
				min.	54	48	38	31	27	24	21	19	—	—	—	—	—	—	—
46Si7	1.5024	+H	880 ± 5	max.	63	60	53	46	42	39	36	34	31	29	28	27	27	26	25
				min.	56	50	40	33	29	26	23	21	—	—	—	—	—	—	—
56Si7	1.5026	+H	850 ± 5	max.	65	62	60	57	54	50	46	42	39	37	36	35	34	34	33
				min.	57	55	49	43	37	34	32	31	28	27	26	26	25	25	24
55Cr3	1.7176	+H	850 ± 5	max.	67	67	66	65	64	63	62	61	57	53	49	46	43	41	40
				min.	57	56	55	54	52	48	43	39	32	30	28	26	25	24	23
60Cr3	1.7177	+H	850 ± 5	max.	66	66	66	65	65	65	65	64	64	63	63	62	62	61	60
				min.	57	57	57	56	56	55	53	50	40	33	30	29	29	28	28
54SiCr6	1.7102	+H	850 ± 5	max.	67	66	66	65	65	64	64	63	59	55	49	44	40	37	35
				min.	57	56	55	50	44	40	37	35	32	30	28	26	25	24	24
56SiCr7	1.7106	+H	850 ± 5	max.	65	65	64	63	62	60	57	54	47	42	39	37	36	36	35
				min.	60	58	55	50	44	40	37	35	32	30	28	26	25	24	24
61SiCr7	1.7108	+H	850 ± 5	max.	68	68	67	65	63	61	60	58	51	46	43	41	39	39	38
				min.	60	59	57	54	49	46	42	39	35	32	31	30	29	28	28
51CrV4	1.8159	+H	850 ± 5	max.	65	65	64	64	63	63	63	62	62	62	61	60	60	59	58
				min.	57	56	55	54	53	51	50	48	44	41	37	35	34	33	32
45SiCrV6-2	1.8151	+H	880 ± 5	max.	65	64	63	62	60	58	57	55	52	49	47	45	43	41	40
				min.	55	54	53	49	45	42	39	37	33	31	29	27	26	25	25
54SiCrV6	1.8152	+H	860 ± 5	max.	67	66	65	63	62	60	57	55	47	43	40	38	37	36	35
				min.	57	56	55	50	44	40	37	35	32	30	28	26	25	24	24
60SiCrV7	1.8153	+H	860 ± 5	max.	66	65	65	64	63	61	59	57	51	46	42	40	38	38	37
				min.	60	59	57	54	49	45	42	39	35	32	31	30	29	28	28
46SiCrMo6	1.8062	+H	880 ± 5	max.	63	63	63	62	61	61	60	59	57	54	52	50	49	49	48
				min.	55	54	53	52	50	48	47	45	42	39	37	35	34	33	33
50SiCrMo6	1.8063	+H	890 ± 5	max.	65	65	64	64	64	64	63	63	63	62	61	61	60	60	59
				min.	57	56	56	55	55	54	54	53	52	51	49	47	45	44	43
52SiCrNi5	1.7117	+H	860 ± 5	max.	63	63	63	62	62	62	61	61	60	59	57	56	54	52	49
				min.	56	56	55	55	54	53	52	51	47	42	38	35	33	31	30
52CrMoV4	1.7701	+H	850 ± 5	max.	67	67	67	67	67	67	67	67	66	66	66	65	65	65	64
				min.	57	56	56	55	53	52	51	50	48	47	46	46	45	44	44
60CrMo3-1	1.7239	+H	850 ± 5	max.	66	66	66	65	65	65	65	64	64	63	63	62	62	61	60
				min.	57	57	57	56	56	56	54	53	50	43	36	32	30	30	30
60CrMo3-2	1.7240	+H	850 ± 5	max.	66	66	66	66	66	65	65	65	65	64	64	64	64	64	64
				min.	57	57	57	57	57	56	56	56	56	54	51	46	43	39	36
60CrMo3-3	1.7241	+H	850 ± 5	max.	66	66	66	66	66	65	65	65	65	64	64	64	64	64	64
				min.	57	57	57	57	57	56	56	56	56	55	55	53	53	52	50

^a See also Figure 1.

Table 8 — Hardness limits for steel types with specified hardenability (+HH, see 7.1.4)

Designation Name	Number	Symbol	Hardening temperature for end-quench test °C	Limits of range ^a	Hardness HRC at a distance, in millimetres, from quenched end of test piece of														
					1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
38Si7	1.5023	+HH	880 ± 5	max.	61	58	51	44	40	37	34	32	29	27	26	25	25	25	24
				min.	56	51	42	35	31	28	25	23	—	—	—	—	—	—	—
46Si7	1.5024	+HH	880 ± 5	max.	63	60	53	46	42	39	36	34	31	29	28	27	27	26	25
				min.	58	53	44	37	33	30	27	25	—	—	—	—	—	—	—
56Si7	1.5026	+HH	850 ± 5	max.	65	62	60	57	54	50	46	42	39	37	36	35	34	34	33
				min.	60	57	53	48	43	39	37	35	32	30	29	29	28	28	28
55Cr3	1.7176	+HH	850 ± 5	max.	67	67	66	65	64	63	62	61	57	53	49	46	43	41	40
				min.	60	60	59	58	56	53	49	46	40	38	35	33	31	30	29
60Cr3	1.7177	+HH	850 ± 5	max.	66	66	66	65	65	65	65	64	64	63	63	62	62	61	60
				min.	60	60	60	59	59	58	57	55	48	43	41	40	40	39	39
54SiCr6	1.7102	+HH	850 ± 5	max.	67	66	66	65	65	64	64	63	59	55	49	44	40	37	35
				min.	60	59	59	55	51	48	46	44	41	38	35	32	30	28	28
56SiCr7	1.7106	+HH	850 ± 5	max.	65	65	64	63	62	60	57	54	47	42	39	37	36	36	35
				min.	62	60	58	54	50	47	44	41	37	34	32	30	29	28	28
61SiCr7	1.7108	+HH	850 ± 5	max.	68	68	67	65	63	61	60	58	51	46	43	41	39	39	38
				min.	63	62	60	58	54	51	48	45	40	37	35	34	32	32	31
51CrV4	1.8159	+HH	850 ± 5	max.	65	65	64	64	63	63	63	62	62	62	61	60	60	59	58
				min.	60	59	58	57	56	55	54	53	50	48	45	43	43	42	41
45SiCrV6-2	1.8151	+HH	880 ± 5	max.	65	64	63	62	60	58	57	55	52	49	47	45	43	41	40
				min.	58	57	56	53	50	47	45	43	39	37	35	33	32	30	30
54SiCrV6	1.8152	+HH	860 ± 5	max.	67	66	65	63	62	60	57	55	47	43	40	38	37	36	35
				min.	60	59	58	54	50	47	44	42	37	34	32	30	29	28	28
60SiCrV7	1.8153	+HH	860 ± 5	max.	66	65	65	64	63	61	59	57	51	46	42	40	38	38	37
				min.	62	61	60	57	54	50	48	45	40	37	35	33	32	31	31
46SiCrMo6	1.8062	+HH	880 ± 5	max.	63	63	63	62	61	61	60	59	57	54	52	50	49	49	48
				min.	58	57	56	55	54	52	51	50	47	44	42	40	39	38	38
50SiCrMo6	1.8063	+HH	890 ± 5	max.	65	65	64	64	64	64	63	63	63	62	61	61	60	60	59
				min.	60	59	59	58	58	57	57	56	56	55	53	52	50	49	48
52SiCrNi5	1.7117	+HH	860 ± 5	max.	63	63	63	62	62	62	61	61	60	59	57	56	54	52	49
				min.	58	58	58	57	57	56	55	54	51	48	44	42	40	38	36
52CrMoV4	1.7701	+HH	850 ± 5	max.	67	67	67	67	67	67	67	67	66	66	66	65	65	65	64
				min.	60	60	60	59	58	57	56	56	54	53	53	52	52	51	51
60CrMo3-1	1.7239	+HH	850 ± 5	max.	66	66	66	65	65	65	65	64	64	63	63	62	62	61	60
				min.	60	60	60	59	59	59	58	57	55	50	45	42	41	40	40
60CrMo3-2	1.7240	+HH	850 ± 5	max.	66	66	66	66	66	65	65	65	65	64	64	64	64	64	64
				min.	60	60	60	60	60	59	59	59	59	57	55	52	50	47	45
60CrMo3-3	1.7241	+HH	850 ± 5	max.	66	66	66	66	66	65	65	65	65	64	64	64	64	64	64
				min.	60	60	60	60	60	59	59	59	59	58	58	57	57	56	55

^a See also Figure 1.

Table 9 — Admissible partial decarburisation

Dimensions in millimetres

Designation		Flat bars		Round bars		Rod	
Name	Number	Thick-ness, δ	Depth of decarburisation max.	Diameter, D	Depth of decarburisation max.	Diameter, D	Depth of decarburisation max.
38Si7 ^a	1.5023	0,15 + 0,012 · δ		$D \leq 10$	0,15	by agreement	
46Si7 ^a	1.5024						
56Si7 ^a	1.5026						
54SiCr6 ^a	1.7102						
56SiCr7 ^a	1.7106						
61SiCr7 ^a	1.7108						
45SiCrV6-2 ^a	1.8151			$10 < D$	0,015 D		
54SiCrV6 ^a	1.8152						
60SiCrV7 ^a	1.8153						
46SiCrMo6 ^a	1.8062						
50SiCrMo6 ^a	1.8063						
52SiCrNi5 ^a	1.7117						
55Cr3	1.7176	0,10 + 0,008 · δ		$D \leq 10$	0,10	by agreement	
60Cr3	1.7177						
51CrV4	1.8159						
52CrMoV4	1.7701			$10 < D$	0,010 D		
60CrMo3-1	1.7239						
60CrMo3-2	1.7240						
60CrMo3-3	1.7241						

^a Localized complete decarburisation cannot always be avoided for the steel grades with high silicon content.

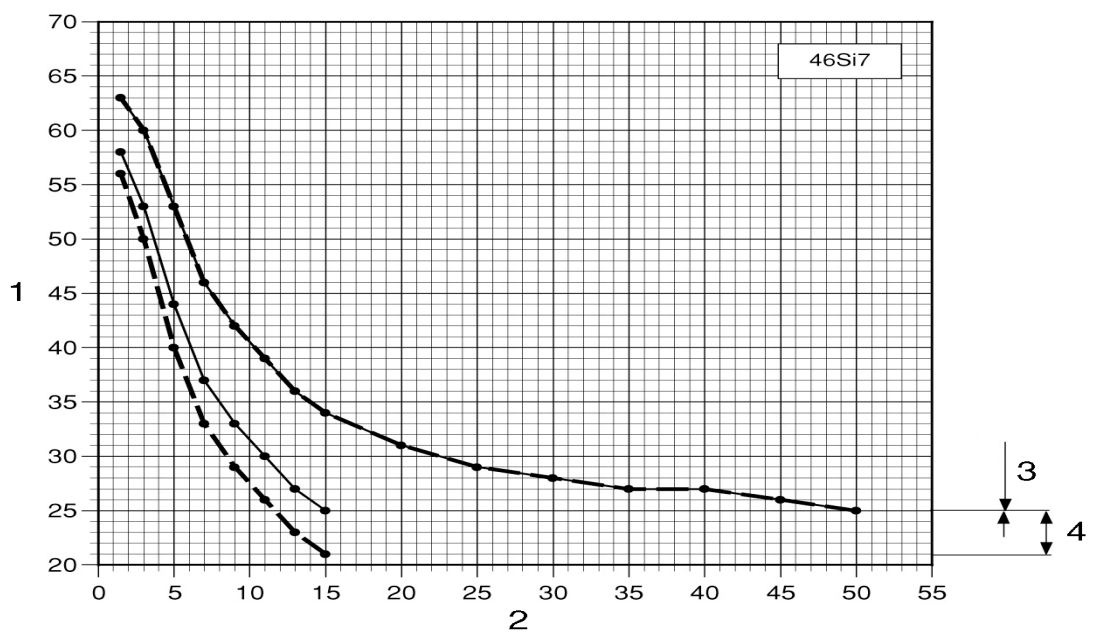
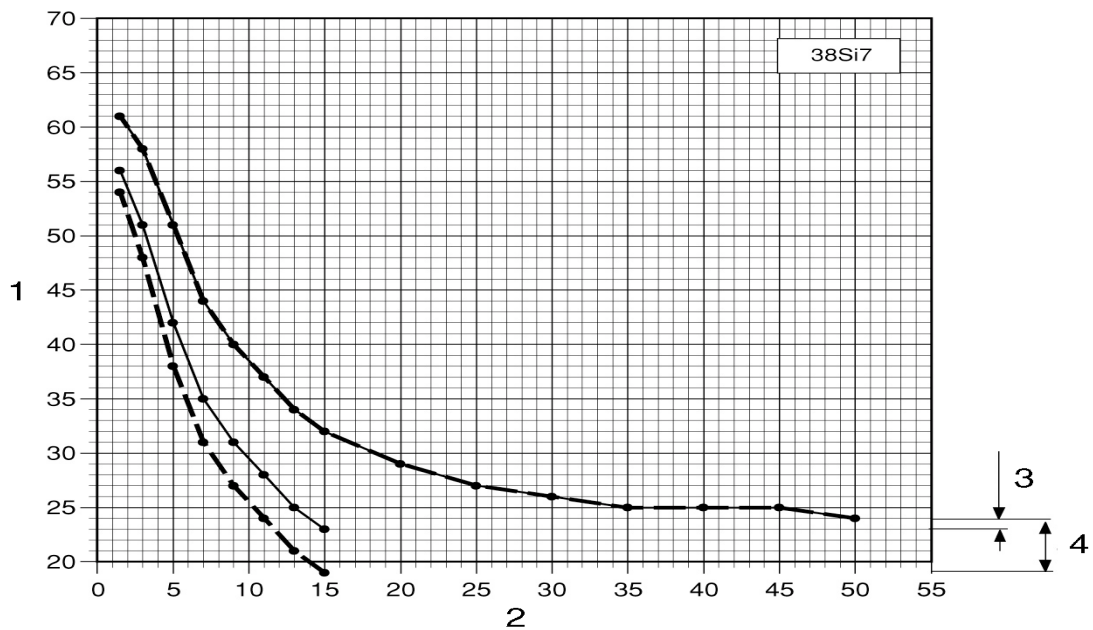
Table 10 — Test conditions for the verification of the requirements (column 2)

NOTE Verification of the requirements is only necessary if an inspection certificate or an inspection report is ordered and if the requirement is applicable according to Table 1, columns 5, 6 or 7.

1	2	3	4	5	6	7	
No.	Requirements	See Table	Amount of testing			Sampling ^a	Test method
			Test unit ^b	Sample products per test unit	Tests per sample product		
1	Chemical composition	3 + 4	C	(The cast analysis is given by the manufacturer; for product analysis, see A.3)			
2	Hardenability (maximum dimension for 80 % (90 %) martensite at the core)	5	C	1	1	The test piece for evaluation of the core hardenability must at least have the cross-sectional dimensions given in Table 5 for a martensite content of 80 % (90 %) at the core. The length of the test piece shall be at least twice its diameter or thickness. The test piece shall be hardened in accordance with the specifications of Table 5 and then be cut transverse to its longitudinal axis.	According to EN ISO 6508-1 (C scales)
3	Hardenability	7 or 8	C	1	1	In cases of dispute, the test piece shall be prepared as follows: a) For diameters ≤ 40 mm, the test piece shall be produced by machining. b) For diameters > 40 mm ≤ 150 mm, the bar shall be reduced by forging to a diameter of 40 mm. c) For diameters > 150 mm, the test piece shall be taken so that its axis is 20 mm below the surface. In all other cases, the sampling method (including the method which starts from separately cast and subsequently hot-worked test ingots or from cast and not hot-worked samples) is left to the discretion of the manufacturer, unless otherwise agreed at the time of enquiry and order.	The test shall be carried out in conformity with EN ISO 642.
4	Hardness in the condition +S, +A or +AC	6	C+D+T	1	1	In cases of dispute, the hardness shall be measured, if possible, at the circumference of the product at a distance of $1 \times$ diameter from one end and, in cases of products with square or rectangular cross section, at a distance of $0,25 \times b$ ($b =$ width of the product) from one longitudinal edge. If the above prescriptions prove unrealistic, a more appropriate position of the hardness indentations shall be agreed upon at the time of enquiry and order.	According to EN ISO 6506-1

^a The general conditions for selection and preparation of test samples and test pieces shall be in accordance with EN ISO 377 and EN ISO 14284.

^b 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".



Key

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

Figure 1 — Scatterbands for end-quench hardenability

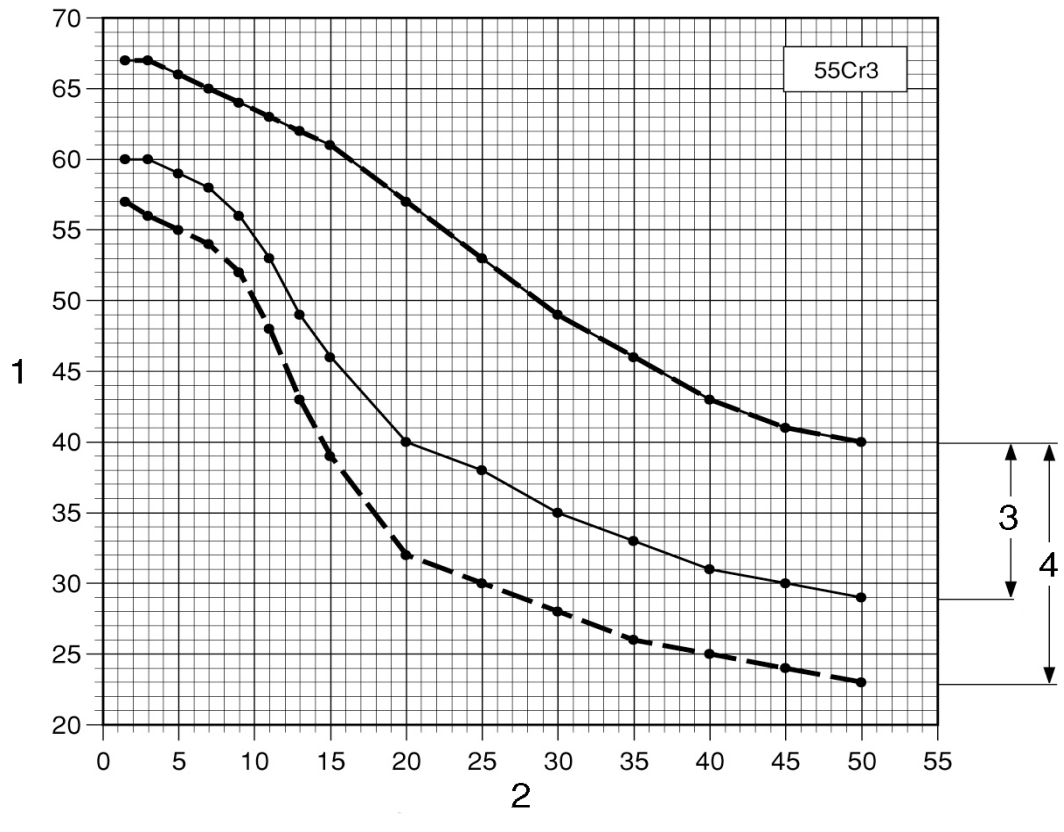
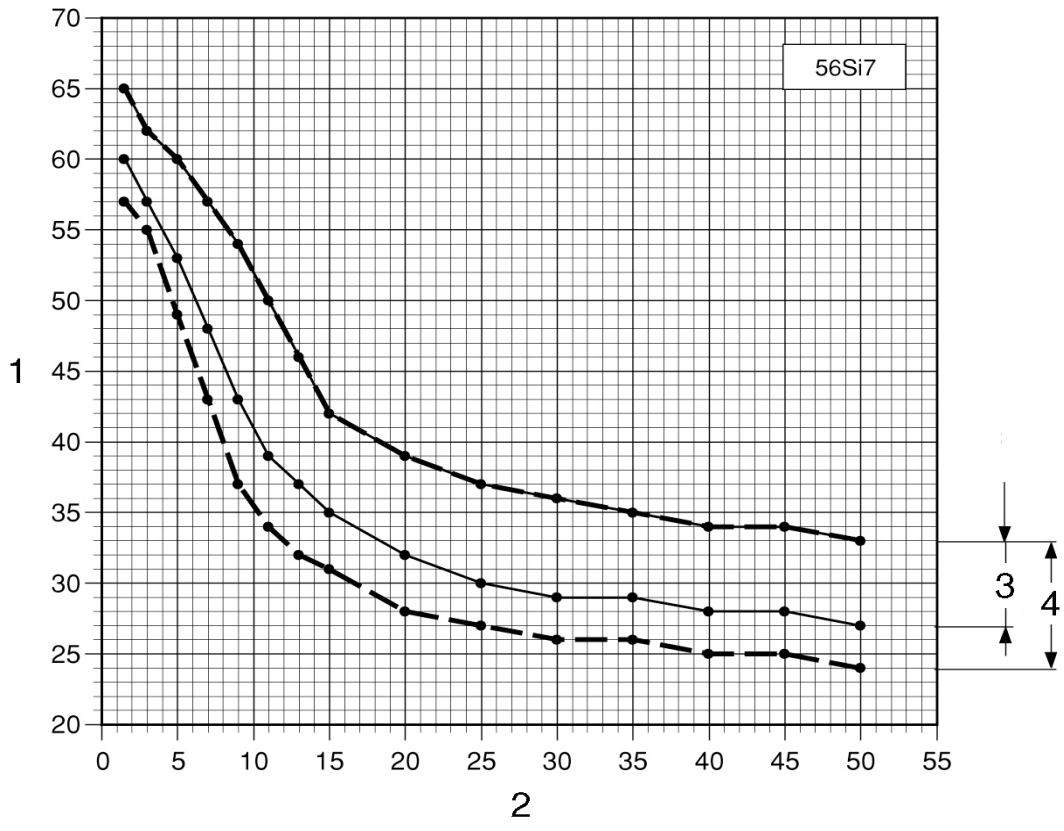


Figure 1 (continued)

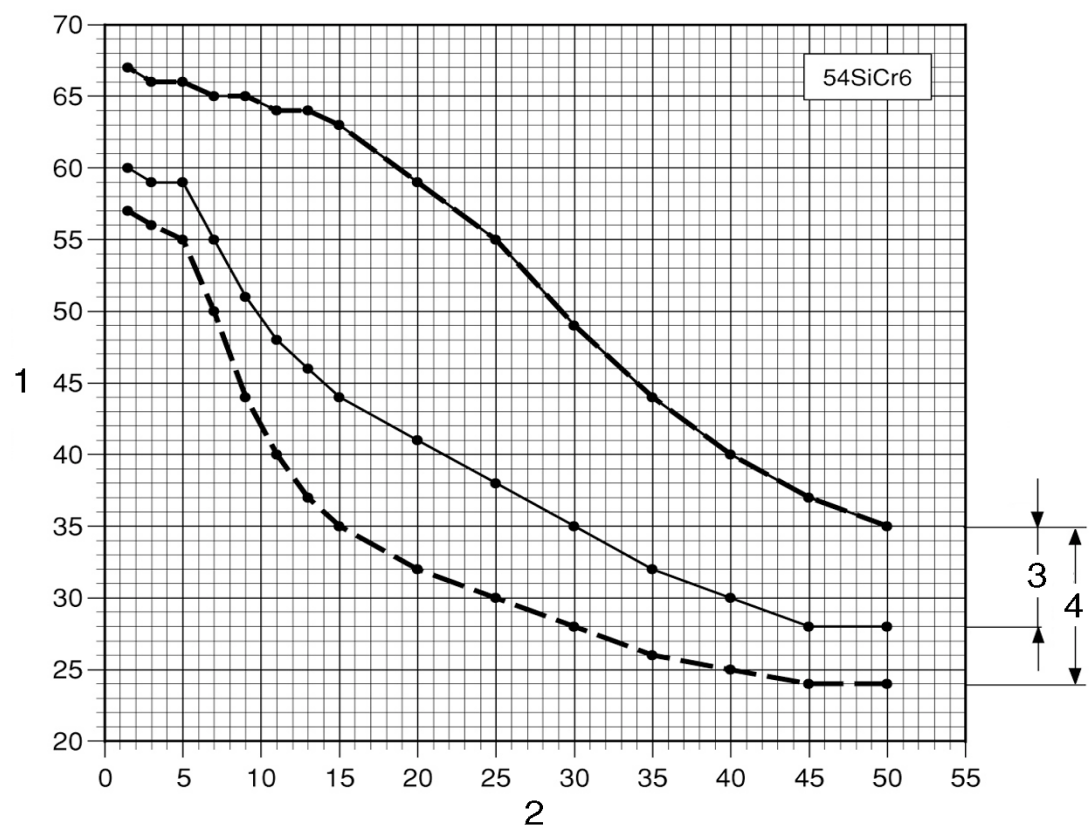
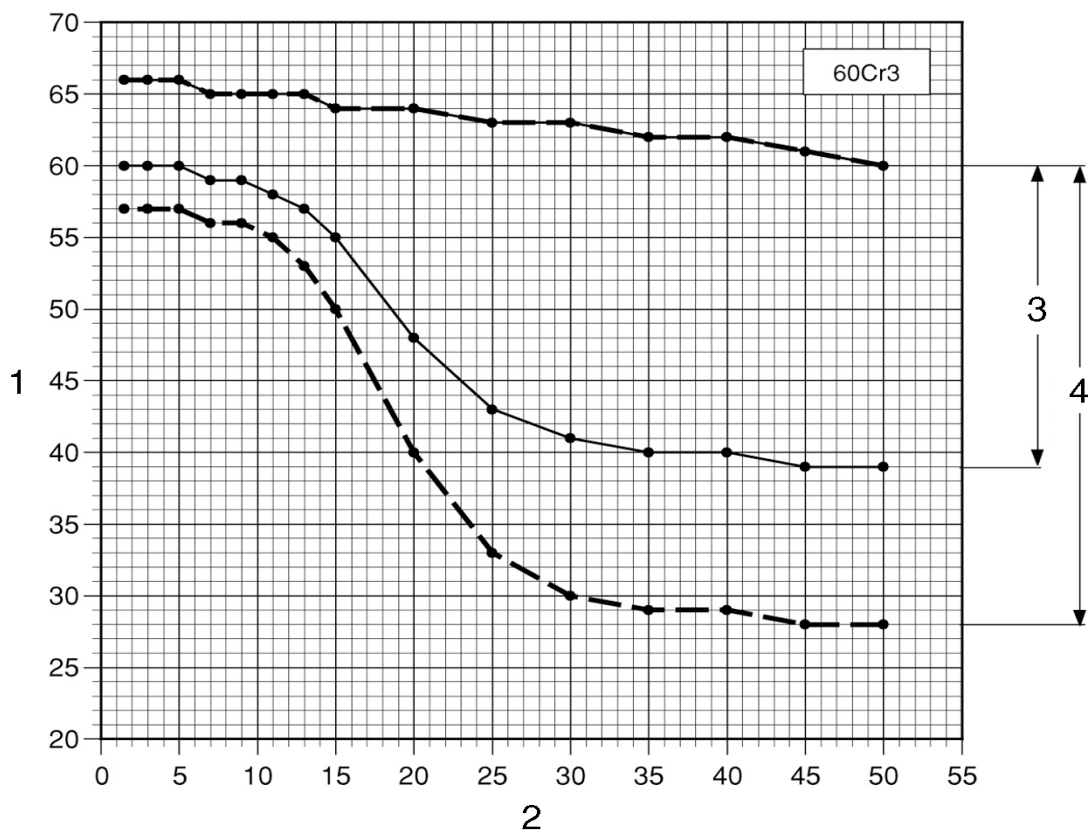


Figure 1 (continued)

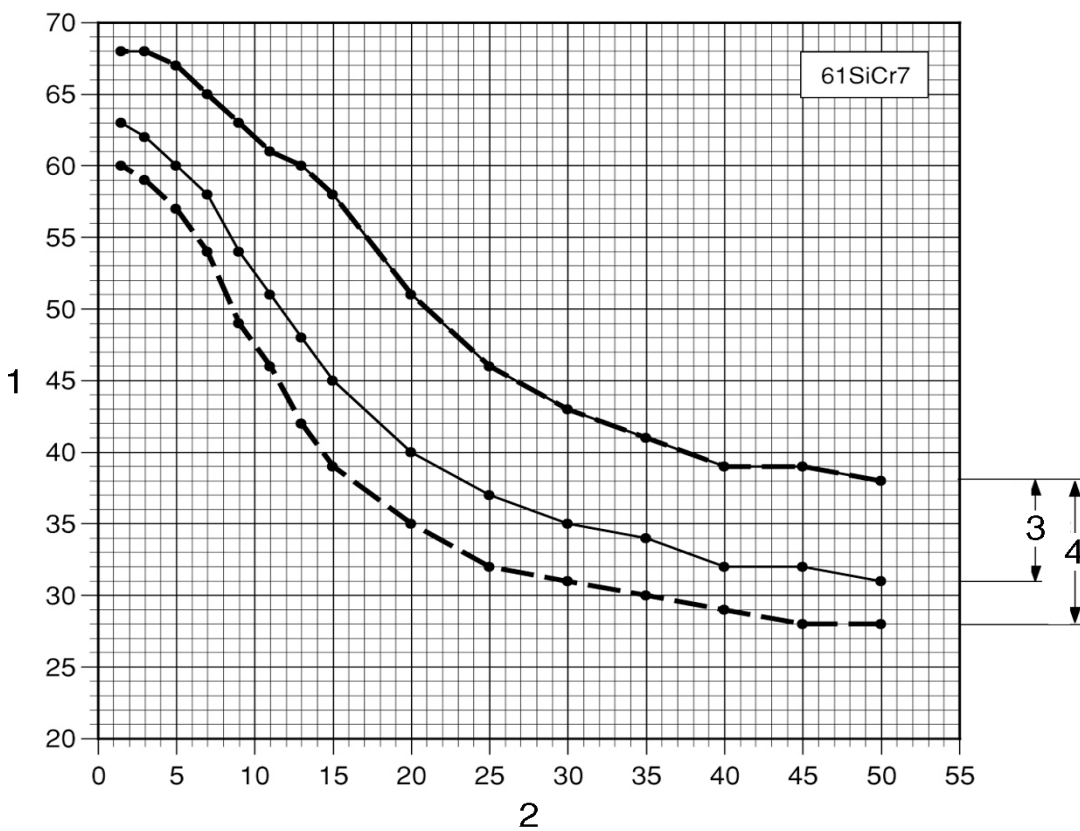
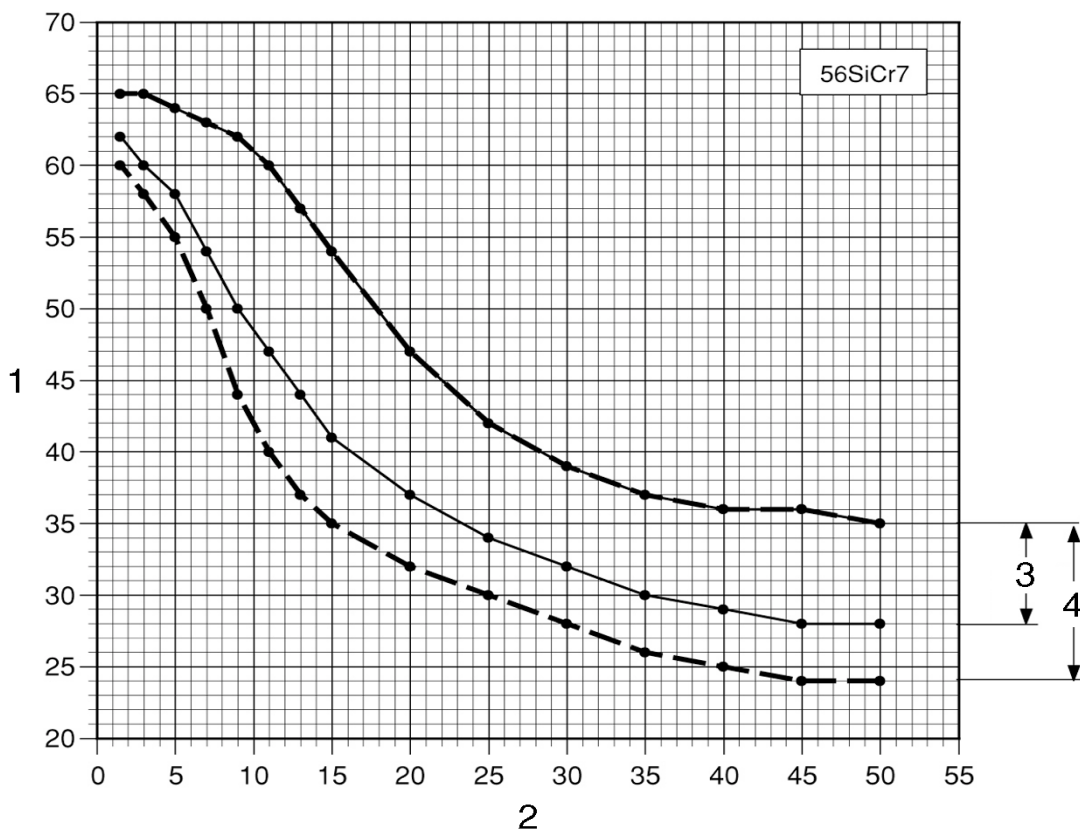


Figure 1 (continued)

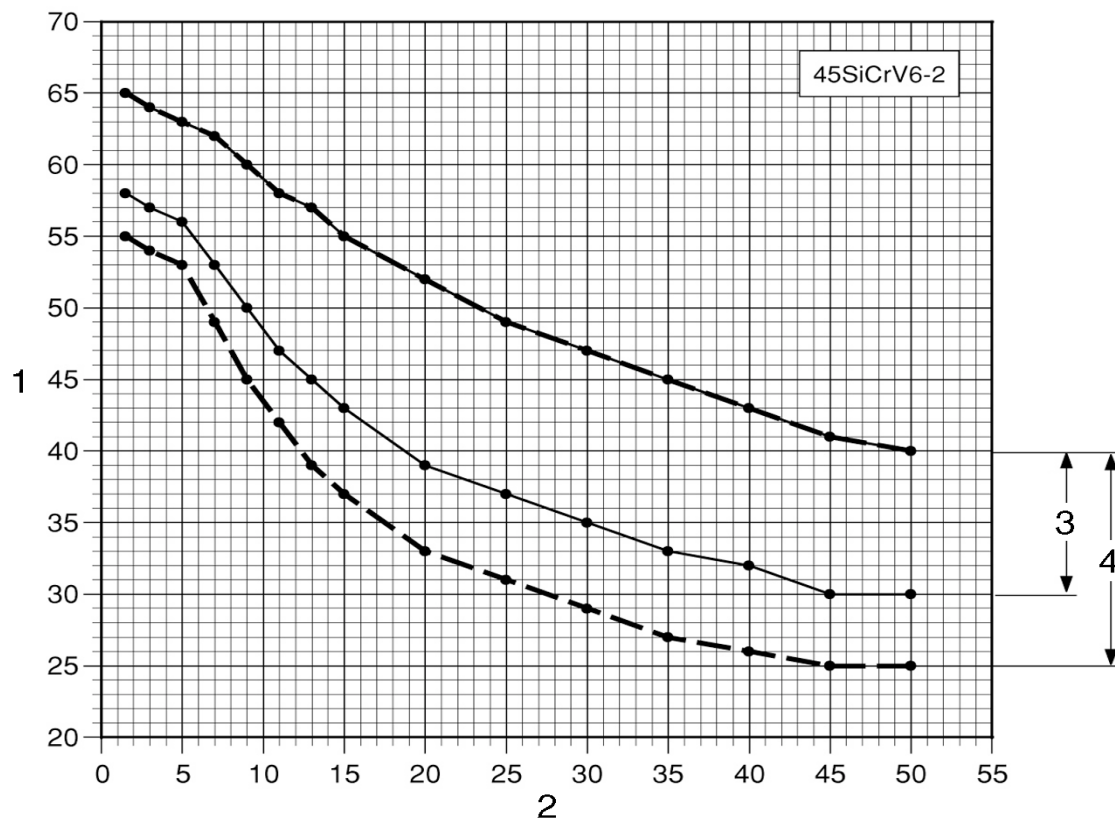
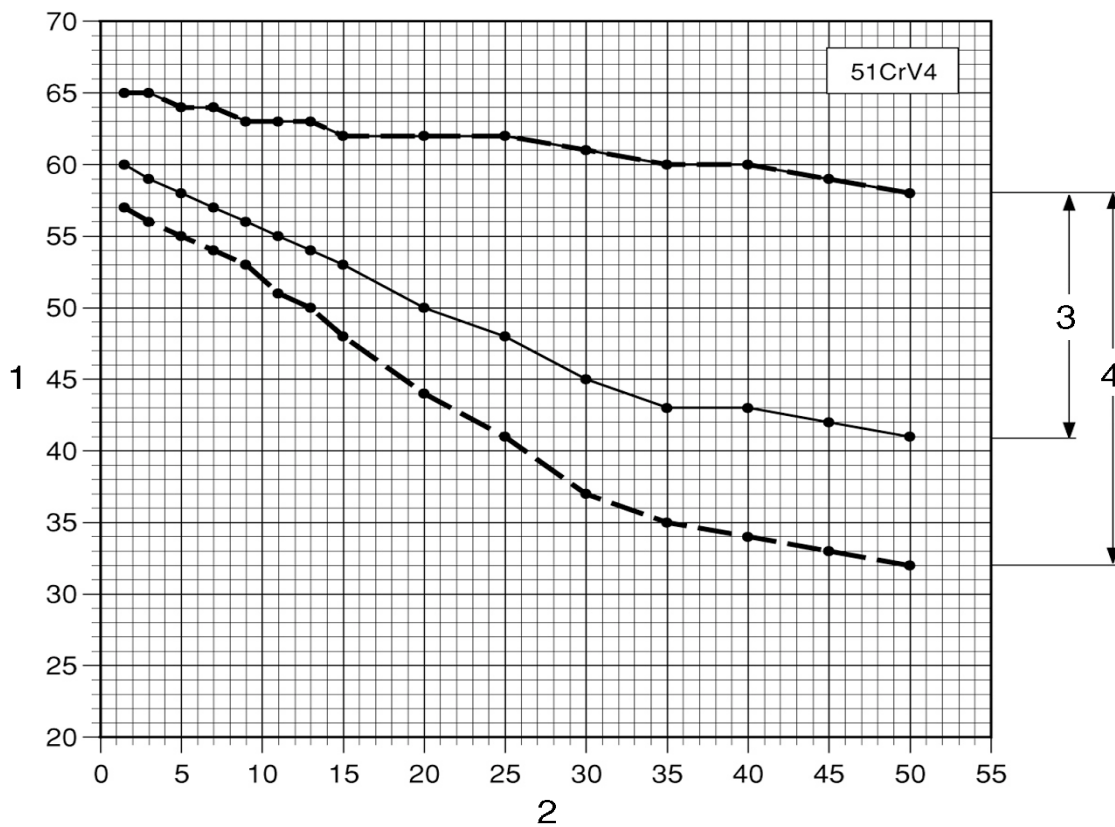


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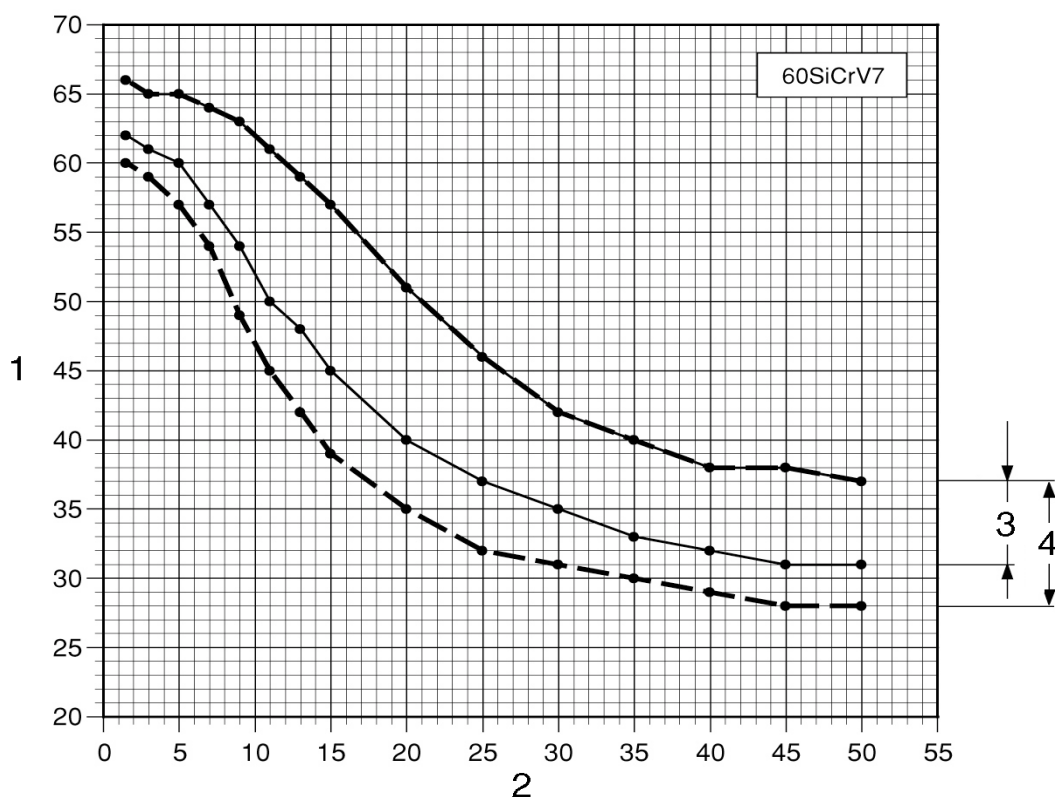
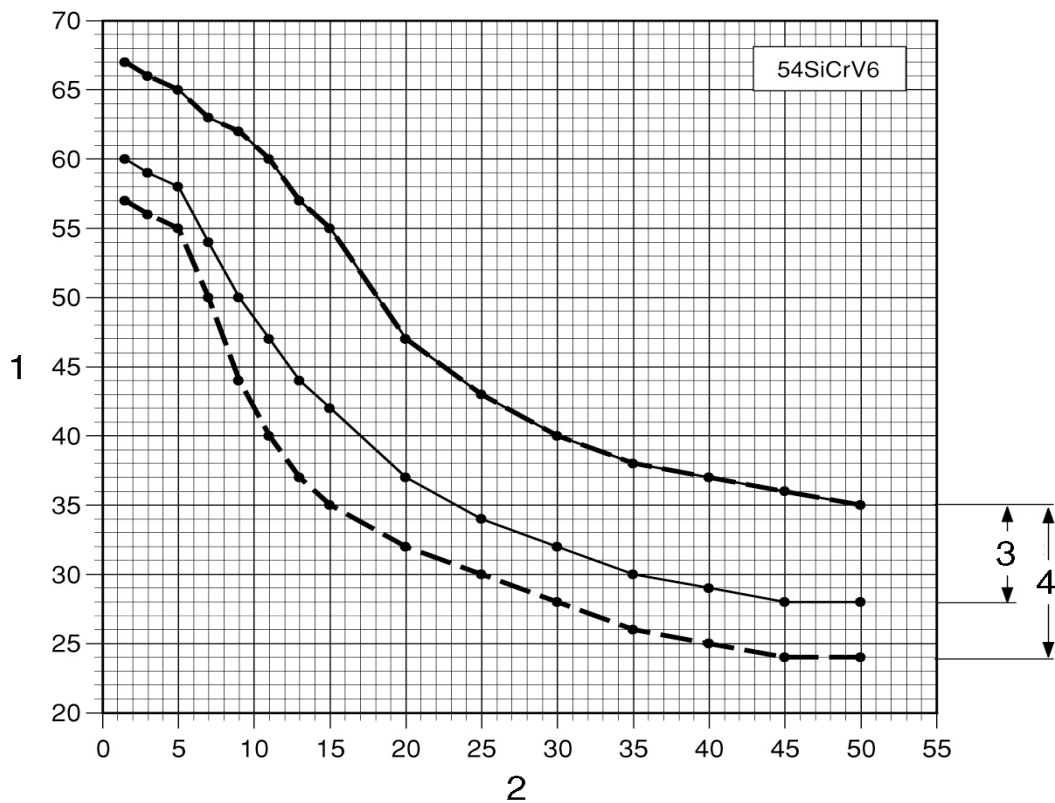


Figure 1 (continued)

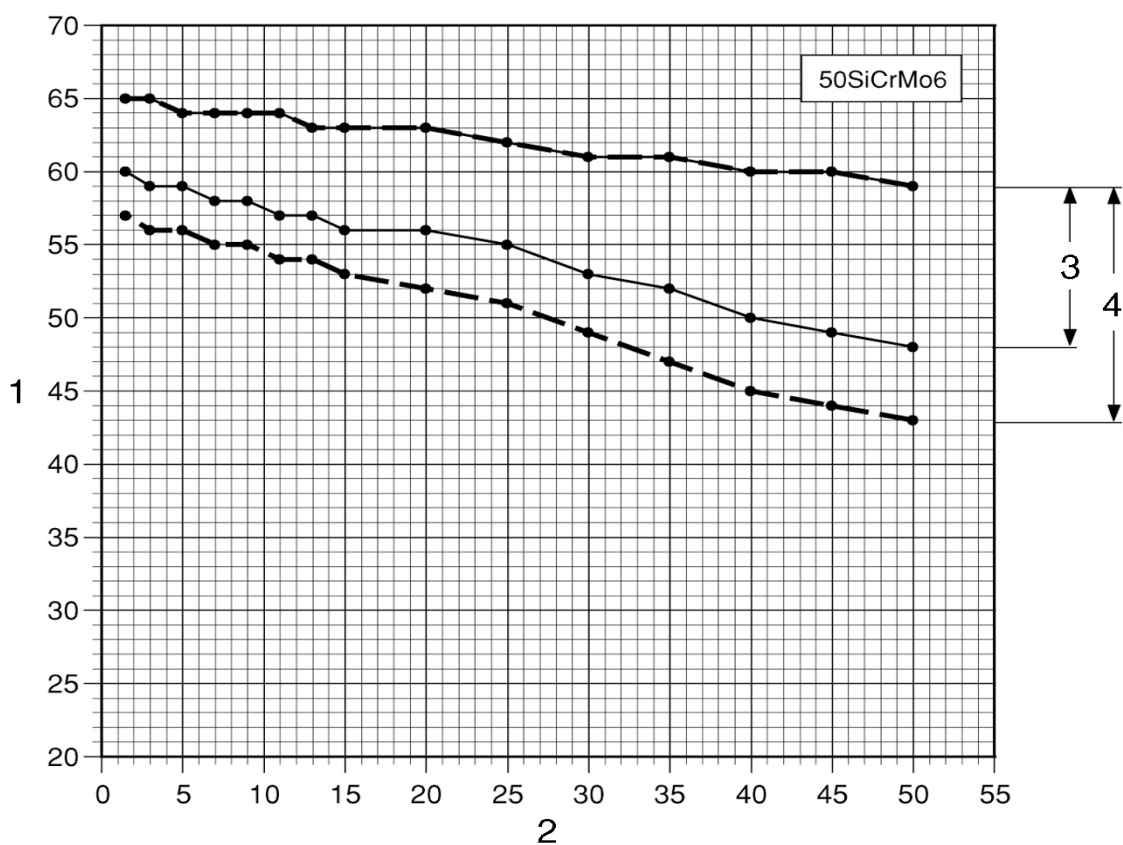
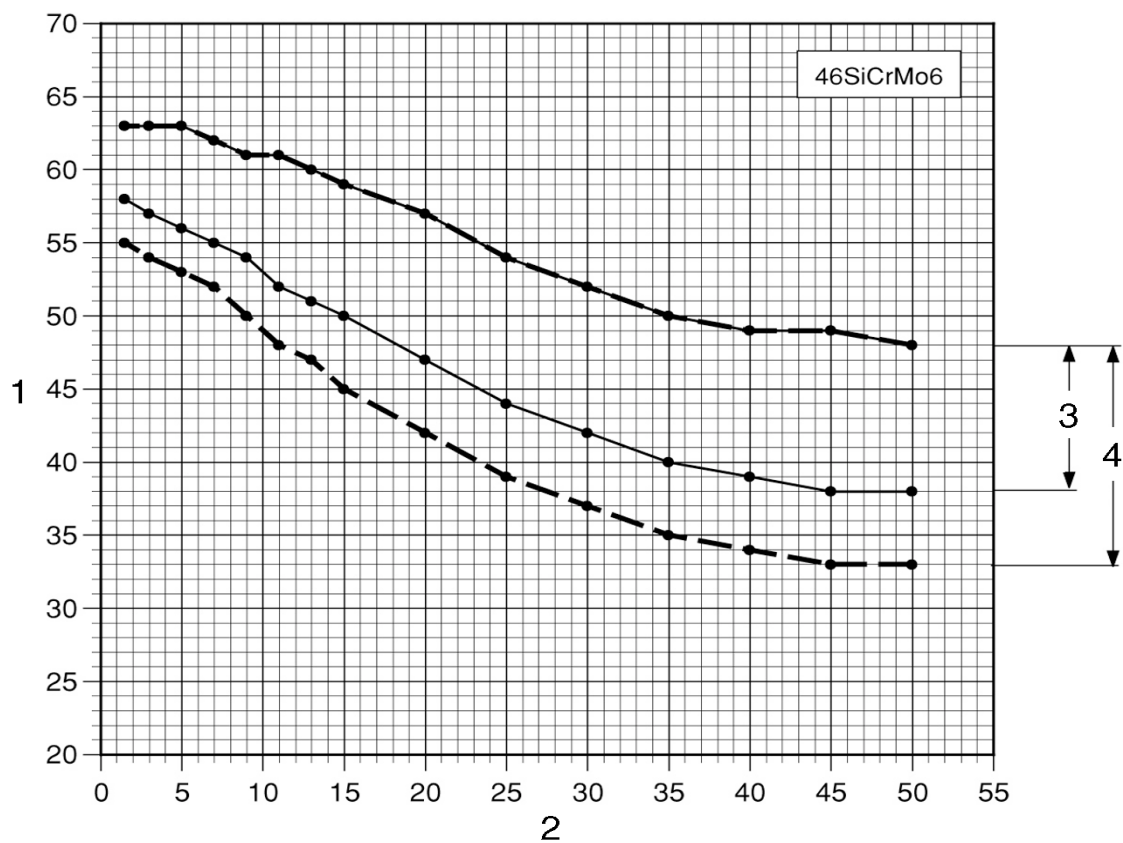


Figure 1 (continued)

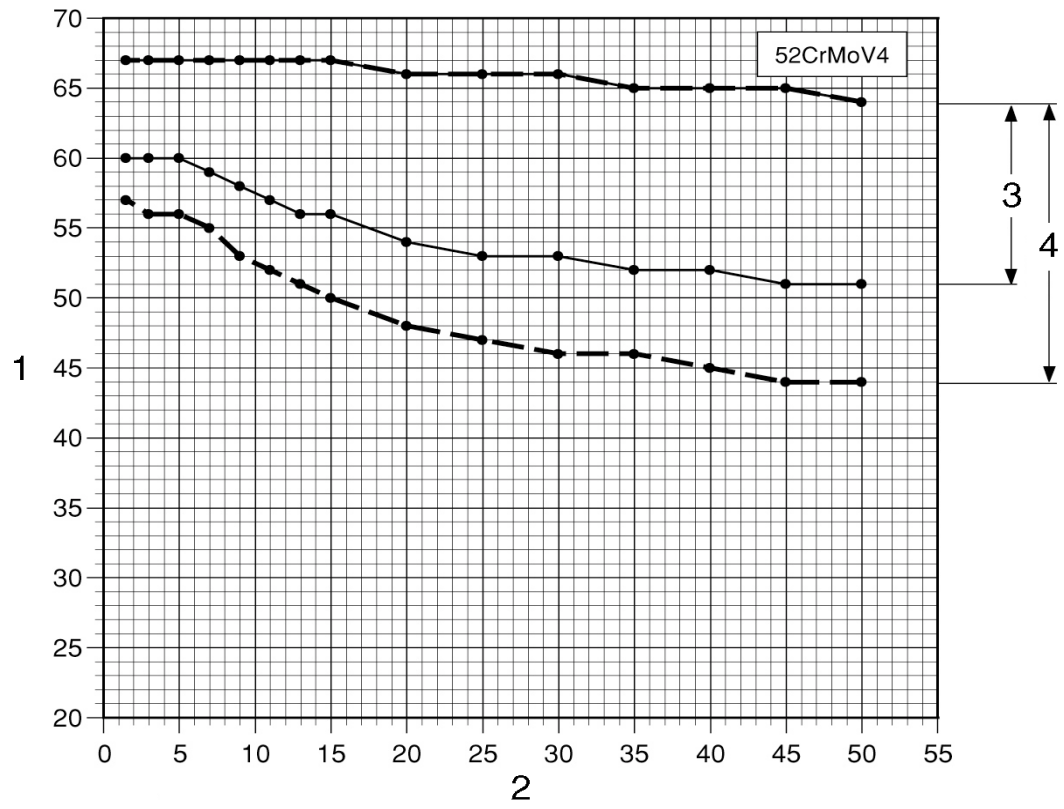
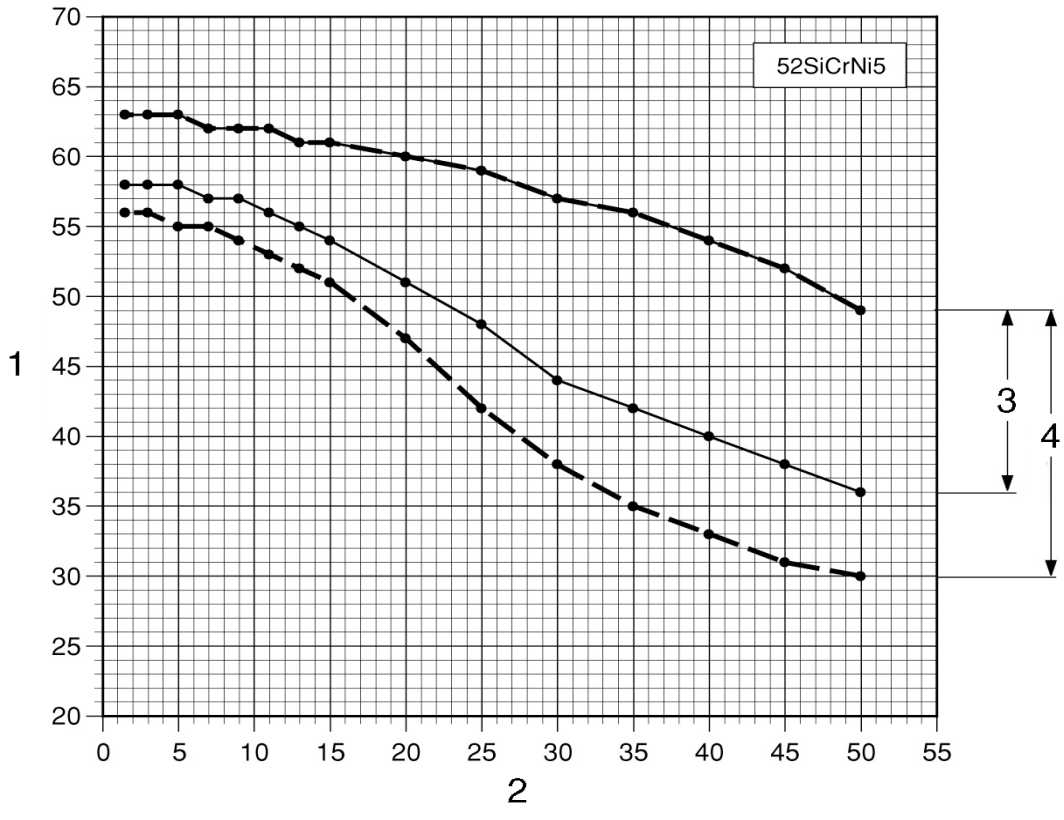


Figure 1 (continued)

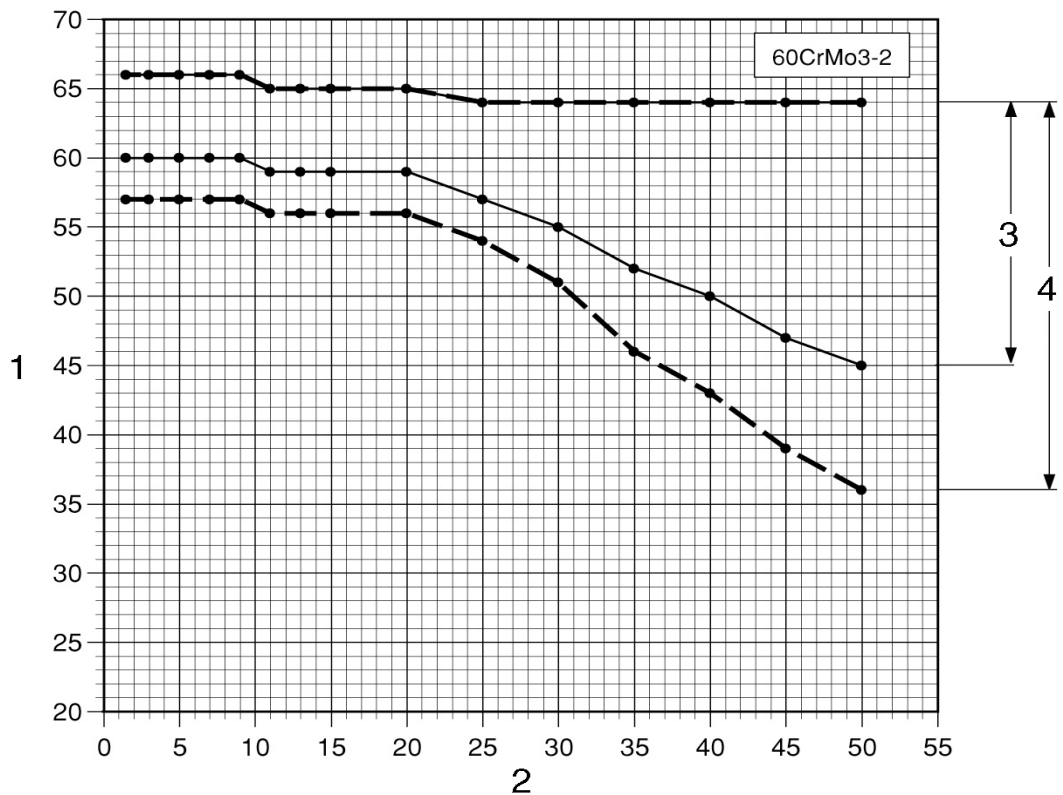
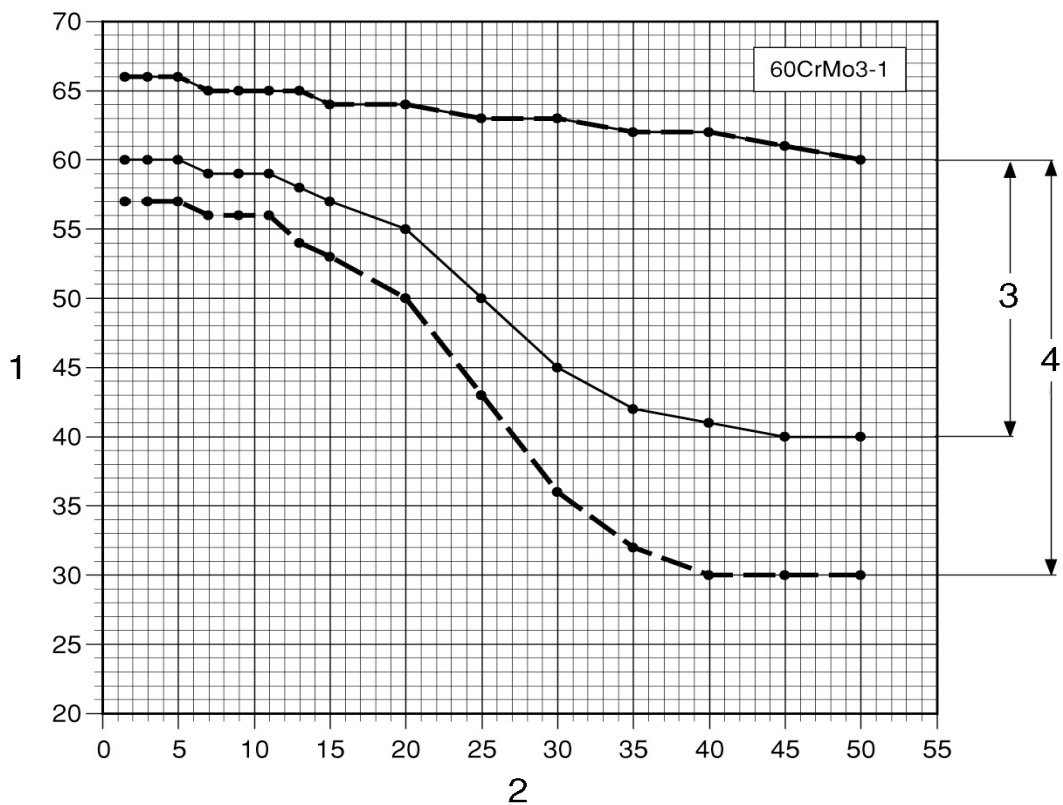


Figure 1 (continued)

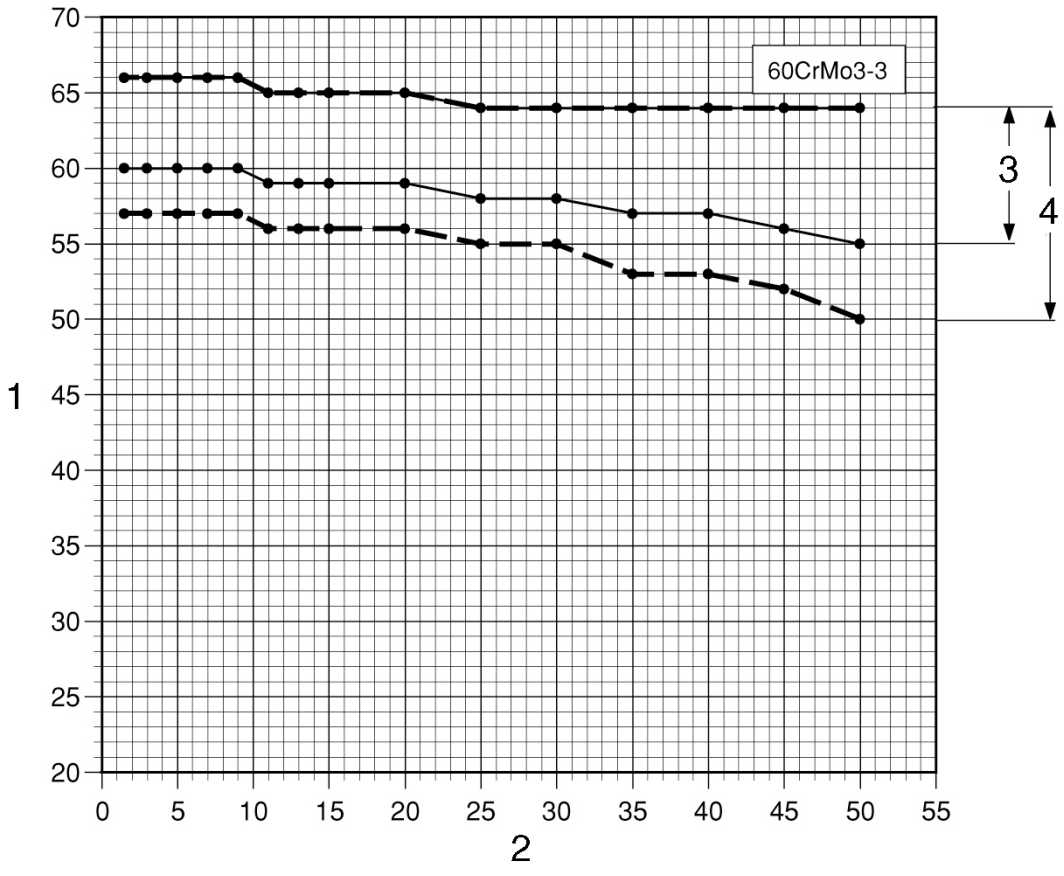


Figure 1 (concluded)

Annex A (normative)

Supplementary or special requirements

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

A.1 Content of non-metallic inclusions

The content of non-metallic inclusions shall be within limits which have been agreed upon, when microscopically determined according to an agreed procedure (for example see ENV 10247).

A.2 Non-destructive testing

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

A.3 Product analysis

One product analysis shall be carried out per cast for 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 listed in CR 10261.

A.4 Special agreements for marking

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

Annex B (informative)

Maximum dimensions for rounds and flats based on the 100% hardenability scatterband (see Table 7)

Table B.1 gives, for information, the maximum dimensions for the normal hardenability scatterband (see NOTE to 7.1.3).

Table B.1 — Maximum dimensions for rounds and flats based on the 100 % hardenability scatterband (provisional values)^a

Steel designation		Steel number	C % by mass min.	Hardness HRC at		Distance from the quenched end A, mm		Maximum dimensions for oil quenched rounds D _{max} , mm		Maximum dimensions for oil quenched flats f _{max} , mm	
				80 % martensite H ₈₀	90 % martensite H ₉₀	80 % martensite A	90 % martensite A	80 % content of martensite at the core	90 % content of martensite at the core	80 % content of martensite at the core	90 % content of martensite at the core
38Si7		1.5023	0,35	44	48	3,8	3	7	5	5	4
46Si7		1.5024	0,42	48	51	3,3	2,8	6	5	4	3
56Si7		1.5026	0,52	52	56	4	2,2	8	3	6	2
55Cr3		1.7126	0,52	52	56	9	3	21	5	15	4
60Cr3		1.7177	0,55	53	57	13	5	33	10	23	7
54SiCr6		1.7102	0,51	52	55	6	5	13	10	9	7
56SiCr7		1.7106	0,52	52	56	6,2	4,5	14	9	10	7
61SiCr7		1.7108	0,57	54	57	7	5	16	10	11	7
51CrV4		1.8159	0,47	50	54	13	7	33	16	23	11
45SiCrV6-2		1.8151	0,40	47	50	8	6,5	19	14	13	10
54SiCrV6		1.8152	0,51	52	55	6	5	13	10	9	7
60SiCrV7		1.8153	0,56	53	57	7,3	5	17	10	12	7
46SiCrMo6		1.8062	0,42	48	51	11	8	27	19	19	13
50SiCrMo6		1.8063	0,46	49	53	30	15	89	39	63	28
52SiCrNi5		1.7117	0,49	51	54	15	9	39	21	28	15
52CrMoV4		1.7701	0,48	50	54	15	8	39	19	28	13
60CrMo3-1		1.7239	0,56	53	57	15	5	39	10	28	7
60CrMo3-2		1.7240	0,56	53	57	26,5	9	76	21	54	15
60CrMo3-3		1.7241	0,56	53	57	40	9	> 100	21	91	15

^a For the hardening test temperature (Jominy test), see Table 7.

Annex C (informative)

Dimensional standards applicable to products complying with this European Standard

For hot rolled rod:

prEN 10017, *Non alloy steel rod for drawing and/or cold rolling — Dimensions and tolerances.*

prEN 10108, *Round steel rod for cold formed nuts and bolts — Dimensions and tolerances.*

For hot rolled bars:

prEN 10058, *Hot rolled flat steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

prEN 10059, *Hot rolled square steel bars for general purposes — Dimensions and tolerances on shape and dimensions.*

prEN 10060, *Hot rolled round steel bars — Dimensions and tolerances on shape and dimensions.*

prEN 10061, *Hot rolled hexagon steel bars — Dimensions and tolerances on shape and dimensions.*

prEN 10092-1, *Hot rolled spring steel flat bars - Part 1: Flat bars - Dimensions and tolerances on shape and dimensions.*

prEN 10092-2, *Hot rolled spring steel flat bars — Part 2: Ribbed and grooved spring leaves — Dimensions and tolerances on shape and dimensions.*

Annex D (informative)

Guidance values for the mechanical properties of quenched and tempered test pieces (maximum dimensions as given in Table 5)

Designation		Quench hardening temperature °C ± 10 °C	Quench hardening medium	Tempering temperature °C ±10 °C	$R_{p0,2}$ MPa min.	R_m MPa	A % min.	Z % min.	Impact energy at 20 °C KU J min.
Name	Number								
38Si7	1.5023	880	Water	450	1150	1300 to 1600	8	35	18
46Si7	1.5024	880	Water	450	1250	1400 to 1700	7	30	15
56Si7	1.5026	860	Oil	450	1300	1450 to 1750	6	25	13
55Cr3	1.7176	840	Oil	400	1250	1400 to 1700	3	20	5
60Cr3	1.7177	840	Oil	400	1300	1450 to 1750	3	20	5
54SiCr6	1.7102	860	Oil	450	1300	1450 to 1750	6	25	8
56SiCr7	1.7106	860	Oil	450	1350	1500 to 1800	6	25	8
61SiCr7	1.7108	860	Oil	450	1400	1550 to 1850	5,5	20	8
51CrV4	1.8159	850	Oil	450	1200	1350 to 1650	6	30	8
45SiCrV6-2	1.8151	880	Oil	400	1550	1600 to 1900	7	40	13
54SiCrV6	1.8152	860	Oil	400	1600	1650 to 1950	5	35	8
60SiCrV7	1.8153	860	Oil	400	1650	1700 to 2000	5	30	5
46SiCrMo6	1.8062	880	Oil	450	1400	1550 to 1850	6	35	10
50SiCrMo6	1.8063	890	Oil	450	1420	1650 to 1950	6	30	5
52SiCrNi5	1.7117	860	Oil	450	1300	1450 to 1750	6	35	10
52CrMoV4	1.7701	860	Oil	450	1300	1450 to 1750	6	35	10
60CrMo3-1	1.7239	860	Oil	450	1300	1450 to 1750	6	30	8
60CrMo3-2	1.7240	860	Oil	450	1300	1450 to 1750	6	30	8
60CrMo3-3	1.7241	860	Oil	450	1300	1450 to 1750	6	30	8

NOTE Sampling and sample preparation should be the same as given in EN 10083-1.

Bibliography

- [1] EN 10083-1, *Quenched and tempered steels — Part 1: Technical delivery conditions for special steels.*
- [2] ENV 10247, *Micrographic examination of the non-metallic inclusion content of steels using standard pictures.*

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