INTERNATIONAL STANDARD

ISO 683-14

Third edition
2004-02-01

Heat-treatable steels, alloy steels and free-cutting steels —

Part 14: Hot-rolled steels for quenched and tempered springs

Aciers pour traitement thermique, aciers alliés et aciers pour décolletage —

Partie 14: Aciers laminés à chaud pour ressorts trempés et revenus

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 683-14 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 4, *Heat treatable and alloy steels*.

This third edition cancels and replaces the second edition (ISO 683-14:1992), which has been technically revised.

ISO 683 consists of the following parts, under the general title *Heat-treatable steels, alloy steels and free-cutting steels*:

— *Part 1: Direct-hardening unalloyed and low-alloyed wrought steel in form of different black products*

— *Part 9: Wrought free-cutting steels*

— *Part 10: Wrought nitriding steels*

— *Part 11: Wrought case-hardening steels*

— *Part 14: Hot-rolled steels for quenched and tempered springs*

— *Part 15: Valve steels for internal combustion engines*

— *Part 17: Ball and roller bearing steels*

— *Part 18: Bright products of unalloyed and low alloy steels*

Heat-treatable steels, alloy steels and free-cutting steels —

Part 14:
Hot-rolled steels for quenched and tempered springs

1 Scope

1.1 This part of ISO 683 gives the technical delivery requirements for round and flat bars and wire rods manufactured from the alloyed steels listed in Table 2, 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 3, lines 2 to 6, and in one of the surface conditions given in Table 1.

NOTE 1 Table 2 only considers steels which have gained certain international importance. This does not, however, mean that these are available in all industrial countries. In addition, a great number of other steels are specified in regional and national standards.

NOTE 2 International Standards relating to steels complying with the chemical composition requirements in Table 2, but supplied in product forms or treatment conditions other than those given in 1.1 or intended for special applications, are given in the Bibliography.

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.

1.3 In addition to this part of ISO 683, the general technical delivery requirements of ISO 404 are applicable.

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.

ISO 377:1997, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 404:1992, *Steel and steel products — General technical delivery requirements*

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

ISO 643:2003, *Steels — Micrographic determination of the apparent grain size*

ISO 1035-1:1980, *Hot-rolled steel bars — Part 1: Dimensions of round bars*

ISO 1035-3:1980, *Hot-rolled steel bars — Part 3: Dimensions of flat bars*

ISO 1035-4:1982, *Hot-rolled steel bars — Part 4: Tolerances*

ISO 3887:2003, *Steels — Determination of depth of decarburization*

ISO 4885:1996, *Ferrous products — Heat treatments — Vocabulary*

ISO 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

ISO/TR 4949:2003, *Steel names based on letter symbols*

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

ISO 6508-1:1999, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 6929:1987: *Steel products — Definitions and classification*

ISO 8457-1:1989, *Steel wire rod — Part 1: Dimensions and tolerances*

ISO 9442:1988, *Steel — Hot-rolled ribbed and grooved flats for spring leaves — Tolerances and dimensions*

ISO 9443:1991, *Heat-treatable and alloy steels — Surface quality classes for hot-rolled round bars and wire rods — Technical delivery conditions*

ISO 10474:1991, *Steel and steel products — Inspection documents*

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

3 Terms and definitions

For the purposes of this part of ISO 683, the terms and definitions given in ISO 4885 and the following apply.

3.1
product forms
See ISO 6929.

3.2
spring steels
steels which are, because of their resilience in the quenched and tempered condition, particularly suitable for the manufacture of springlike components of all kinds

NOTE The resilience of a steel depends on its elastic deformability, which enables it 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 increasing carbon content and alloying constituents such as silicon, manganese, chromium, molybdenum and vanadium, and also by heat-treatment, i.e. hardening in oil with subsequent tempering.

3.3
alloy steel
See 3.1.3 of ISO 4948-1:1982.

4 Ordering and designation

The designation of the product in an order shall cover the following:

a) The designation of the product form (bar, wire rod) followed by

- either the designation of the dimensional standard and the dimensions and tolerances selected from it (see 5.7) or
- the designation of the drawing or any other document covering the dimensions and tolerances required for the product;

b) if a surface condition other than “hot-worked” or a special surface quality is required:

— the surface condition (see Table 1) and

— the surface quality (see 5.6);

c) a description of the steel, comprising

1) a reference to this part of ISO 683,

2) the designation of the steel type given in Table 2 and, where appropriate, the symbols for the core hardness grade (see 5.2.3) or the restricted hardenability grade (see 5.2.4),

3) if a heat-treatment condition other than the untreated condition is required, the symbol for this other condition (see Table 3, column 2),

4) if an inspection document is required, the standard designation for the required type of document (see ISO 10474),

5) if any supplementary requirement shall be complied with, the symbol and, where necessary, the details of this supplementary requirement (see Annex A).

EXAMPLE To be ordered are:

Hot-rolled round bars

— in accordance with ISO 1035-1;

— with a nominal diameter of 20,0 mm;

— with a nominal length of 8 000 mm;

— with a diameter tolerance of ± 0,25 mm (= class S of ISO 1035-4);

— with a length tolerance of 0 mm to 100 mm (= class L2 of ISO 1035-4);

— all other tolerances as given in ISO 1035-4, for normal cases.

Surface

— shot blast cleaned (symbol BC, see Table 1).

Steel

— according to this part of ISO 683, type 51CrV4 (see Table 2);

— heat-treatment condition: soft annealed (symbol +A, see Table 3);

— with an inspection certificate 3.1.B (see ISO 10474).

Designation

Rounds ISO 1035-1-20,0 S × 8 000 L2

Surface BC

Steel ISO 683-14-51CrV4+A-3.1.B

Table 1 — Surface condition at delivery

1	2	3	4	5	6
1	**Surface condition at delivery**		**Symbol**	**In general applicable for**	
				bar	wire rod
2	Unless otherwise agreed	As hot-worked	None or HW	×	×
3	Particular conditions supplied by agreement	HW + pickled	PI	×	×
4		HW + shot blasted	BC	×	×
5		HW + surface removal[a]	—	×	×
6		Others			

[a] The type of surface removal may be agreed upon, e.g., by reference to the relevant dimensional standard.

Table 2 — Types of steel and specified chemical composition (applicable to cast analysis)

Steel [a] designation		**Comparable type in ISO 683-14:1992**	**Chemical composition [b, c] [% (m/m)]**								
Number	Name[d]		**C**	**Si**	**Mn**	**P**[e] max.	**S**[e] max.	**Cr**	**Mo**	**V**	**Cu + Sn**
1	38Si7	—	0,35 to 0,42	1,50 to 1,80	0,50 to 0,80	0,030	0,030	—	—	—	Cu + 10Sn ⩽ 0,60
2	46Si7	—	0,42 to 0,50	1,50 to 2,00	0,50 to 0,80	0,030	0,030	—	—	—	
3	60Si8	1	0,56 to 0,64	1,80 to 2,20	0,70 to 1,00	0,030	0,030	—	—	—	
4	56SiCr7	2	0,52 to 0,60	1,60 to 2,00	0,70 to 1,00	0,030	0,030	0,20 to 0,40	—	—	
5	61SiCr7	3	0,57 to 0,65	1,60 to 2,00	0,70 to 1,00	0,030	0,030	0,20 to 0,40	—	—	
6	55SiCr6-3	4	0,51 to 0,59	1,20 to 1,60	0,50 to 0,80	0,030	0,030	0,50 to 0,80	—	—	
7	55SiCrV6-3	—	0,51 to 0,59	1,20 to 1,60	0,50 to 0,80	0,030	0,030	0,50 to 0,80	—	0,10 to 0,20	
8	55Cr3	5	0,52 to 0,59	⩽ 0,40	0,70 to 1,00	0,030	0,030	0,70 to 1,00	—	—	
9	60Cr3	—	0,55 to 0,65	⩽ 0,40	0,70 to 1,10	0,030	0,030	0,70 to 1,00	—	—	
10	60CrMo3-3	8	0,56 to 0,64	⩽ 0,40	0,70 to 1,00	0,030	0,030	0,70 to 1,00	0,25 to 0,35	—	
11	51CrV4	9	0,47 to 0,55	⩽ 0,40	0,70 to 1,10	0,030	0,030	0,90 to 1,20	—	0,10 to 0,25	
12	52CrMoV4	10	0,48 to 0,56	⩽ 0,40	0,70 to 1,00	0,030	0,030	0,90 to 1,20	0,15 to 0,25	0,10 to 0,20	

[a] Unalloyed steels also for the production of springs are covered by the wire rod specification in ISO 16120-4.

[b] Elements which are not mentioned should not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions should be taken to prevent the addition, from scrap or other material used during manufacture, of elements which could affect the hardenability, mechanical properties and application.

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

[d] These designations are in accordance with ISO/TR 4949.

[e] Lower maximum values may be agreed at the time of enquiry and order.

Table 3 — Combinations of usual heat-treatment conditions on delivery, product forms and requirements according to Table 2 and Tables 4 to 8

<table>
<tr><td>1</td><td colspan="2">2</td><td colspan="2">3</td><td>4</td><td colspan="5">5</td><td colspan="3">6</td><td colspan="3">7</td></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Heat treatment condition on delivery</td><td rowspan="3">Symbol</td><td colspan="2">Applicable for</td><td rowspan="3"></td><td colspan="5">Applicable requirements</td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td rowspan="2">Bars (rounds and flats) and ribbed and grooved bars</td><td rowspan="2">Wire rod</td><td colspan="3">Unless otherwise agreed</td><td colspan="3">If the steel is ordered with the designation given in Table 8</td><td colspan="3">If the steel is ordered with the designation given in Table 5</td></tr>
<tr><td>i</td><td colspan="2">ii</td><td>iii</td><td>i</td><td>ii</td><td>iii</td><td>i</td><td>ii</td><td>iii</td></tr>
<tr><td>2</td><td>Untreated</td><td>None or +U</td><td>×</td><td>×</td><td rowspan="4">Chemical composition according to Tables 2 and 4. See footnote c in Table 2</td><td colspan="2">–</td><td rowspan="4">Hardenability values according to Table 7</td><td rowspan="4" colspan="2">As in columns 5 (i) and 5 (ii)</td><td rowspan="4">Restricted hardenability values according to Table 8</td><td rowspan="4" colspan="2">As in columns 5 (i) and 5 (ii)</td><td rowspan="4">Maximum diameter or thickness for core hardness according to Table 5</td></tr>
<tr><td>3</td><td>Treated to improve shear-ability</td><td>+S</td><td>×</td><td>—</td><td rowspan="3">Maximum Brinell hardness according to Table 6</td><td>Column +S</td></tr>
<tr><td>4</td><td>Soft annealed</td><td>+A</td><td>×</td><td>×</td><td>Column +A</td></tr>
<tr><td>5</td><td>Annealed to achieve spheroidi-zation of the carbides</td><td>+AC</td><td>×</td><td>×</td><td>Column +AC</td></tr>
<tr><td>6</td><td>Others</td><td colspan="13">Other treatment conditions may be agreed upon at the time of enquiry and order.</td></tr>
</table>

Table 4 — Permissible deviations between specified analysis and product analysis

Element	**Permissible maximum content according to cast analysis** x % (mass fraction)	**Permissible deviation**[a] % (mass fraction)
C	$x \leqslant 0{,}55$	± 0,03
	$0{,}55 < x \leqslant 0{,}65$	± 0,04
Si	$x \leqslant 0{,}40$	± 0,03
	$0{,}40 < x \leqslant 2{,}20$	± 0,05
Mn	$x \leqslant 1{,}00$	± 0,04
	$1{,}00 < x \leqslant 1{,}70$	± 0,05
P	$x \leqslant 0{,}030$	+ 0,005
S	$x \leqslant 0{,}030$	+ 0,005
Cr	$x \leqslant 1{,}20$	± 0,05
Mo	$x \leqslant 0{,}30$	± 0,03
	$0{,}30 < x \leqslant 0{,}35$	± 0,04
V	$x \leqslant 0{,}25$	± 0,02

[a] "±" means that in one cast the deviation may occur over the upper or under the lower value of the specified range in Table 2, but not both at the same time.

Table 5 — Maximum dimensions for flats and rounds (provisional values)

1	2			3			4	
Type of steel	**Minimum core hardness after quenching**[a] HRC	**Maximum dimensions**[b] **for** flats (thickness) mm	rounds (diameter) mm	**Minimum core hardness after quenching**[c] HRC	**Maximum dimensions**[b] **for** flats (thickness) mm	rounds (diameter) mm	**Heat treatment for verifying the maximum dimensions** Quenching temperature °C	Quenching agent
60Si8+CH	54	11	17	56	9	15	830 to 860	Oil
56SiCr7+CH	54	13	20	56	11	18	830 to 860	Oil
61SiCr7+CH	54	16	25	56	14	22	830 to 860	Oil
55SiCr6-3+CH	54	20	33	56	18	30	830 to 860	Oil
55SiCrV6-3+CH	54	22	35	56	18	30	830 to 860	Oil
55Cr3+CH	54	14	21	56	10	16	830 to 860	Oil
60Cr3+CH	54	[d]	[d]	56	[d]	[d]	830 to 860	Oil
60CrMo3-3+CH	54	55	85	56	51	80	830 to 860	Oil
51CrV4+CH	54	25	40	56	20	30	830 to 860	Oil
52CrMoV4+CH	54	35	55	56	29	45	830 to 860	Oil

[a] Larger proportions of bainite are to be expected.

[b] The values are derived from the lower hardenability curve for 2/3-hardenability range (see Table 8).

[c] Small proportions of bainite are to be expected.

[d] Maximum dimensions may be agreed at the time of enquiry and order.

Table 6 — Maximum hardness in different heat-treated conditions

Type of steel	**Maximum Brinell hardness in the heat-treated condition**		
	Treated to improve shearability + S	Soft annealed + A	Annealed to achieve spheroidization of the carbides + AC
38Si7	280	217	200
46Si7	280	248	230
60Si8	280	248	230
56SiCr7	280	248	230
61SiCr7	280	248	230
55SiCr6-3	280	248	230
55SiCrV6-3	280	248	230
55Cr3	280	248	230
60Cr3	280	248	230
60CrMo3-3	280	248	230
51CrV4	280	248	230
52CrMoV4	280	248	230

Table 7 — Hardness limits (tentative values) for steel types with specified hardenability (100 % range) (H-grades, see 5.2.2)

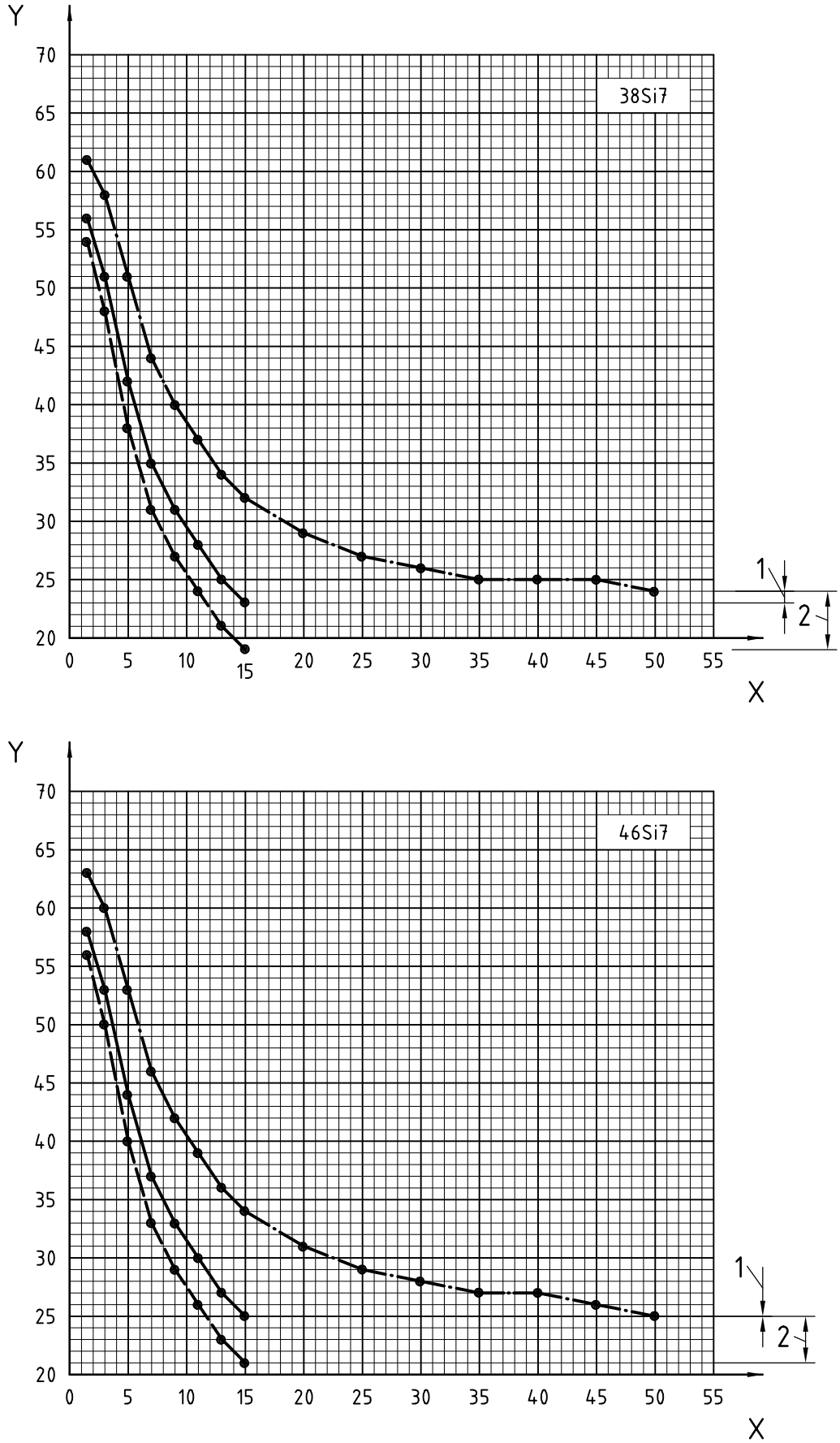
Type of steel	Quenching temperature for end-quench test °C	Limits of range	Hardness HRC at a distance, in millimetres, from quenched end of test piece of														
			1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
38Si7+H	880 ± 5	max.	61	58	51	44	40	37	34	32	29	27	26	25	25	25	24
		min.	54	48	38	31	27	24	21	19	—	—	—	—	—	—	—
46Si7+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	—	—	—	—	—	—	—
60Si8+H	850 ± 5	max.	65	65	65	64	62	60	58	53	44	40	37	35	34	33	32
		min.	59	58	53	46	37	34	32	31	28	27	25	24	24	24	24
56SiCr7+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+H	850 ± 5	max.	68	68	67	65	63	61	60	58	51	46	43	41	39	39	38
		min.	60	59	57	54	48	45	42	39	35	32	31	30	29	28	28
55SiCr6-3+H	850 ± 5	max.	66	66	66	65	65	64	64	63	59	55	49	44	40	37	35
		min.	57	56	56	55	53	52	50	46	36	32	29	28	27	26	25
55SiCrV6-3+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
55Cr3+H	850 ± 5	max.	65	65	64	63	63	62	61	60	57	52	48	45	42	40	39
		min.	57	56	55	54	52	48	43	39	33	30	28	27	26	25	24
60Cr3+H	850 ± 5	max.	66	66	65	65	64	63	62	62	60	57	52	48	45	44	43
		min.	59	59	57	56	53	50	45	41	35	32	30	29	28	27	26
60CrMo3-3+H	850 ± 5	max.	65	65	65	65	65	65	65	65	64	64	63	63	63	63	63
		min.	60	60	60	60	60	60	60	59	58	56	54	50	46	43	41
51CrV4+H	850 ± 5	max.	65	65	64	64	63	62	62	61	60	58	57	55	54	53	53
		min.	57	56	55	54	53	52	50	48	44	41	37	35	34	33	32
52CrMoV4+H	850 ± 5	max.	65	65	64	64	63	63	63	62	62	62	62	61	61	61	60
		min.	57	56	56	56	54	52	51	50	48	47	46	46	45	44	44

NOTE See also Figure 1.

Table 8 — Hardness limits (tentative values) for steel types with specified hardenability (restricted range) (HH-Grades, see 5.2.4)

Type of steel	Quenching temperature for end-quench test °C	Limits of range	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+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+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	—	—	—	—	—	—	—
60Si8+HH	850 ± 5	max.	65	65	65	64	62	60	58	53	44	40	37	35	34	33	32
		min.	61	60	57	52	45	43	41	38	33	31	29	28	27	27	27
56SiCr7+HH	850 ± 5	max.	65	65	64	63	62	60	57	54	47	42	39	37	36	36	35
		min.	61	60	58	54	50	47	44	40	37	34	32	30	29	28	28
61SiCr7+HH	850 ± 5	max.	68	68	67	65	63	61	60	58	51	46	43	41	39	39	38
		min.	63	62	60	58	53	50	48	45	40	37	35	34	32	32	31
55SiCr6-3+HH	850 ± 5	max.	66	66	66	65	65	64	64	63	59	55	49	44	40	37	35
		min.	60	59	59	58	57	56	55	52	44	40	36	33	31	30	28
55SiCrV6-3+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
55Cr3+HH	850 ± 5	max.	65	65	64	63	63	62	61	60	57	52	48	45	42	40	39
		min.	60	59	58	57	56	53	49	46	41	37	35	33	31	30	29
60Cr3+HH	850 ± 5	max.	66	66	65	65	64	63	62	62	60	57	52	48	45	44	43
		min.	61	61	60	59	57	54	51	48	44	41	38	36	34	33	32
60CrMo3-3+HH	850 ± 5	max.	65	65	65	65	65	65	65	65	64	64	63	63	63	63	63
		min.	62	62	62	62	62	62	62	61	60	59	57	54	52	50	48
51CrV4+HH	850 ± 5	max.	65	65	64	64	63	62	62	61	60	58	57	55	54	53	53
		min.	60	59	58	57	56	55	54	52	49	47	44	42	41	40	39
52CrMoV4+HH	850 ± 5	max.	65	65	64	64	63	63	63	62	62	62	62	61	61	61	60
		min.	60	59	59	59	57	56	55	54	53	52	51	51	50	50	49

NOTE See also Figure 1.



Key

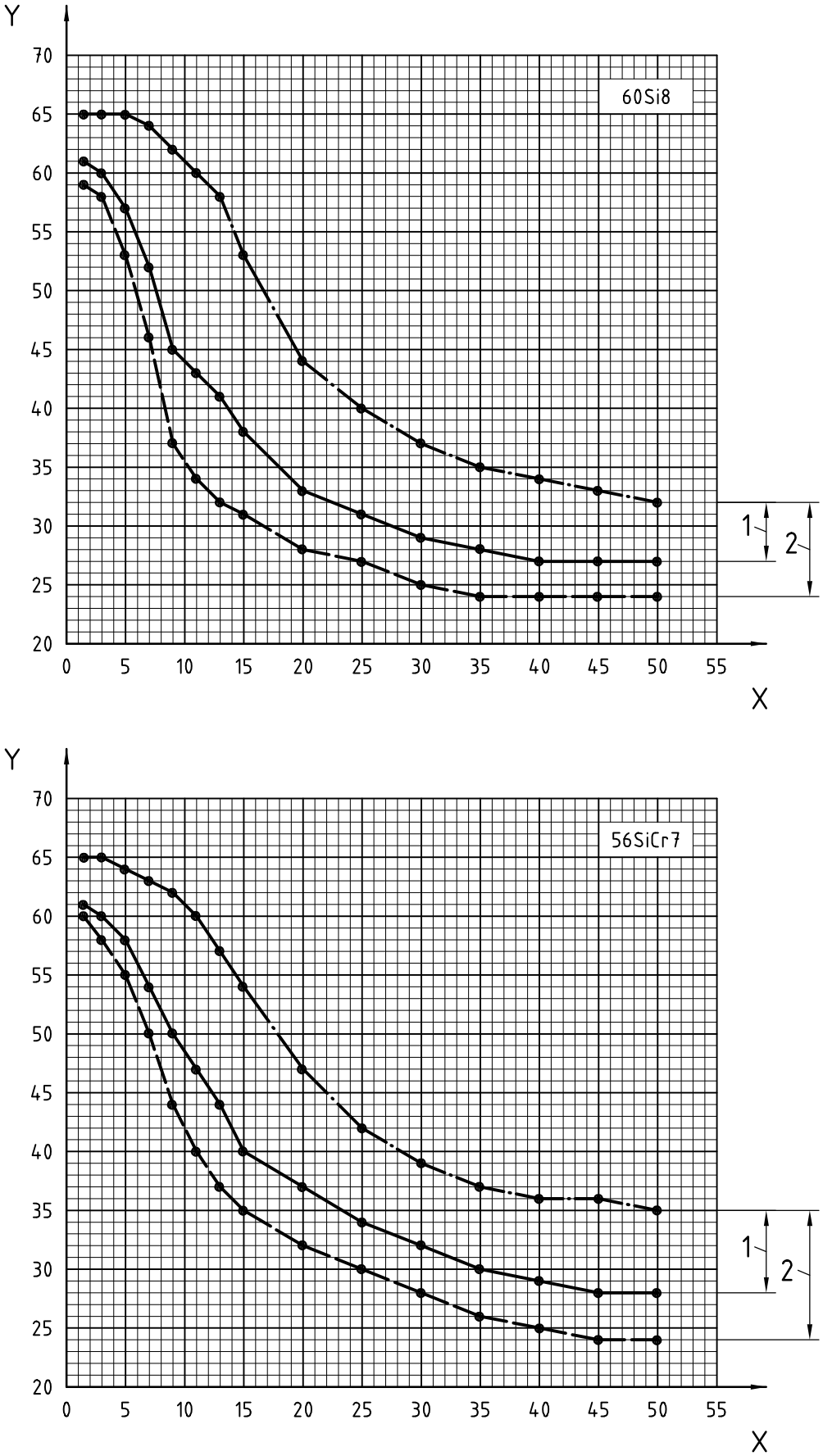
X Distance from quenched end of test piece, mm

Y Hardness, HRC

1 HH-grade

2 H-grade

Figure 1 — Scatterbands for end-quench hardenability



Key

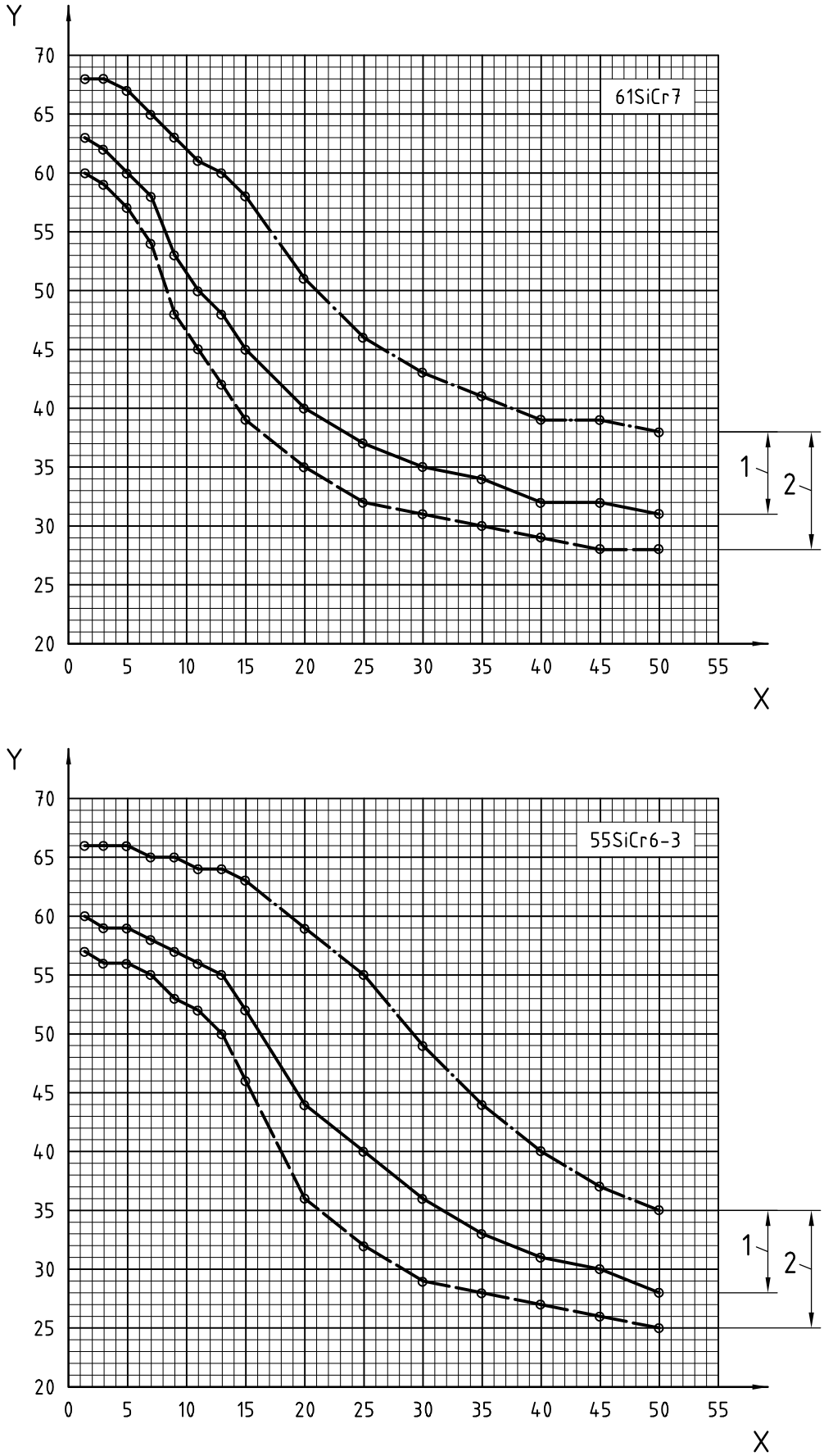
X Distance from quenched end of test piece, mm

Y Hardness, HRC

1 HH-grade

2 H-grade

Figure 1 — (*continued*)



Key

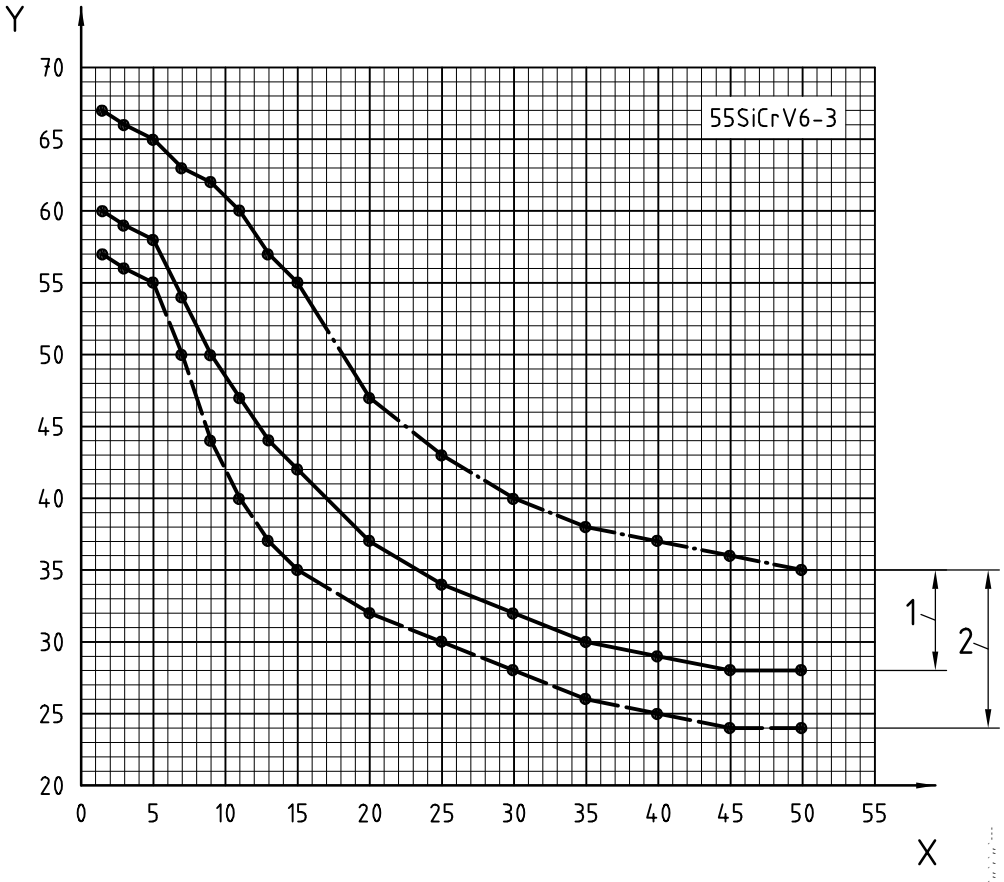
X Distance from quenched end of test piece, mm

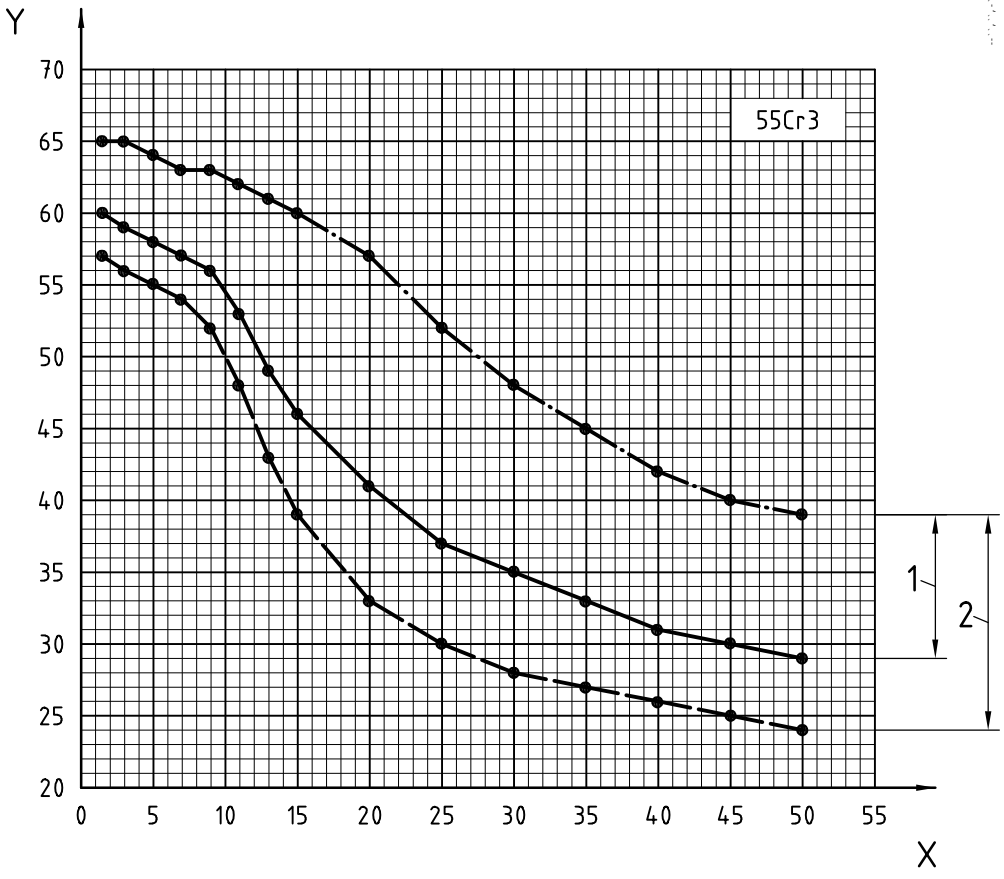
Y Hardness, HRC

1 HH-grade

2 H-grade

Figure 1 — (*continued*)





Key

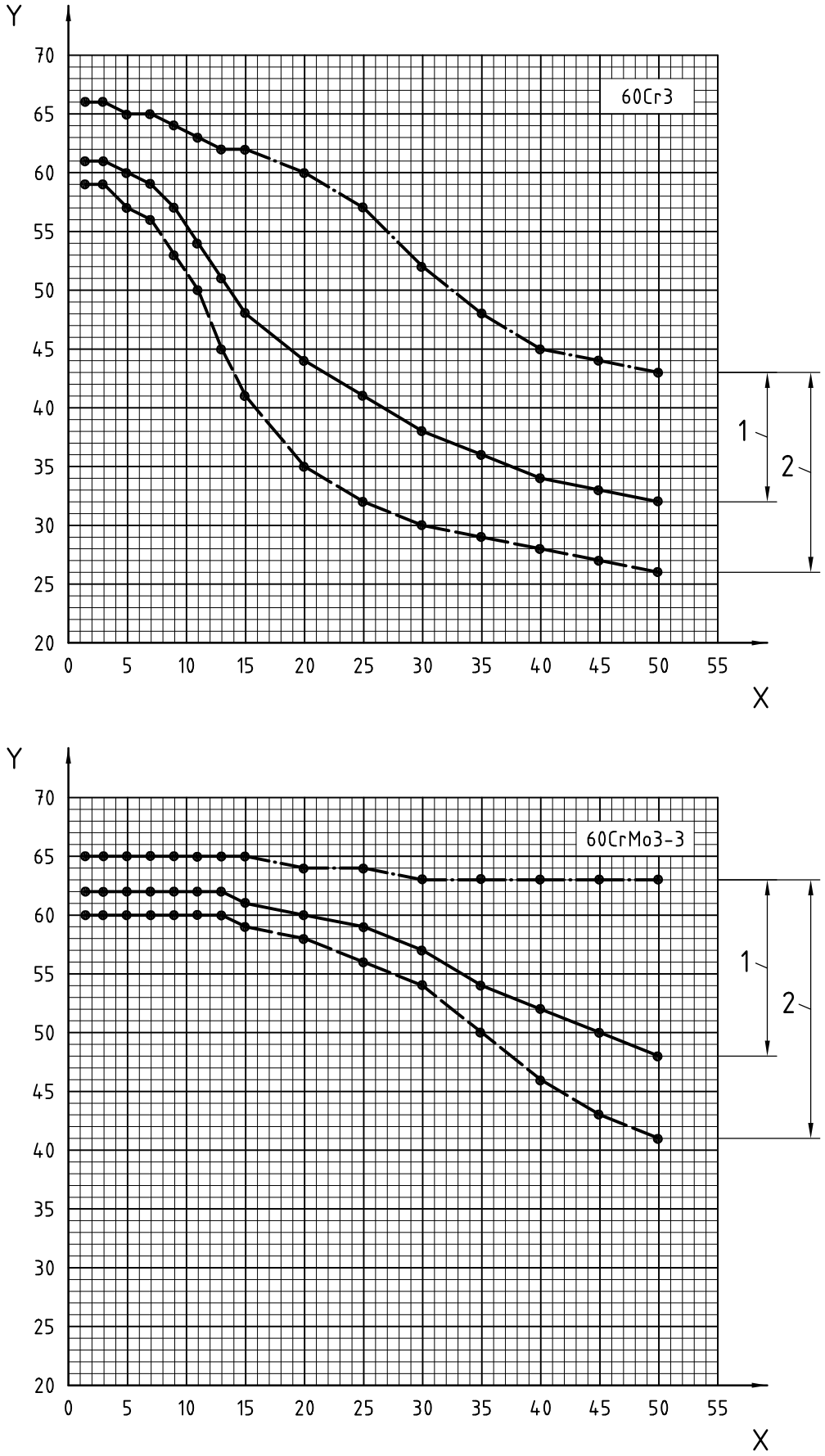
X Distance from quenched end of test piece, mm

Y Hardness, HRC

1 HH-grade

2 H-grade

Figure 1 — (*continued*)



Key

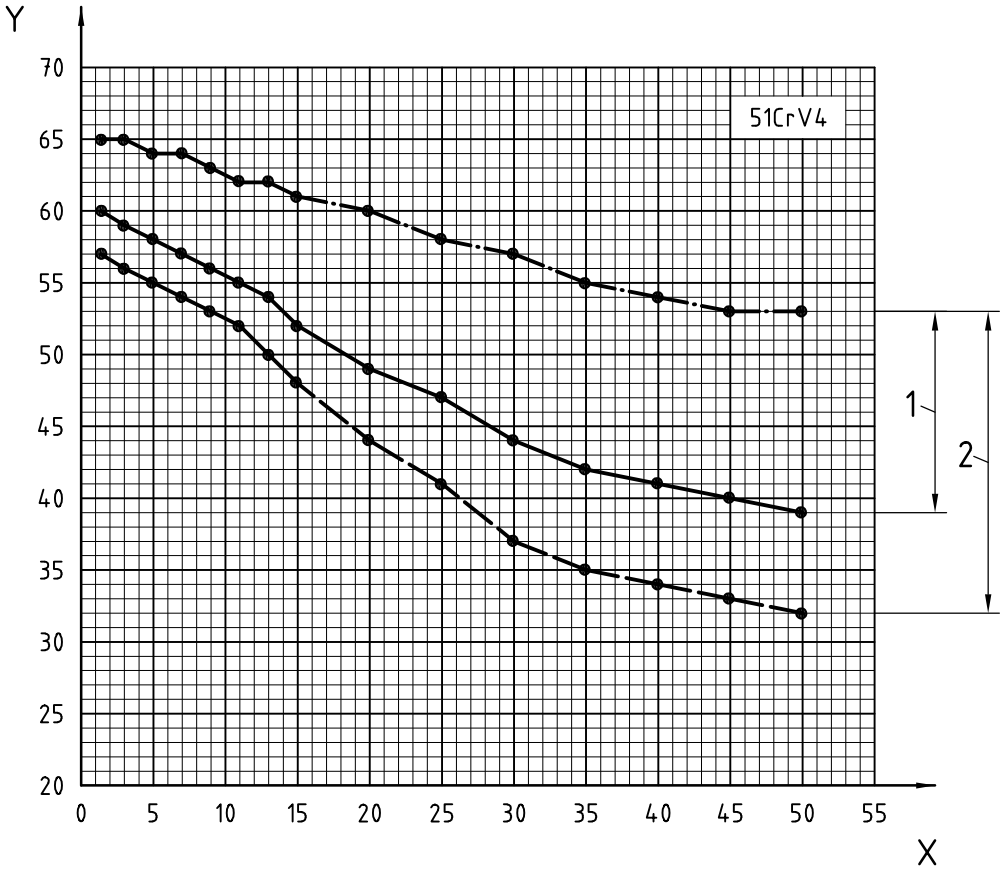
X Distance from quenched end of test piece, mm

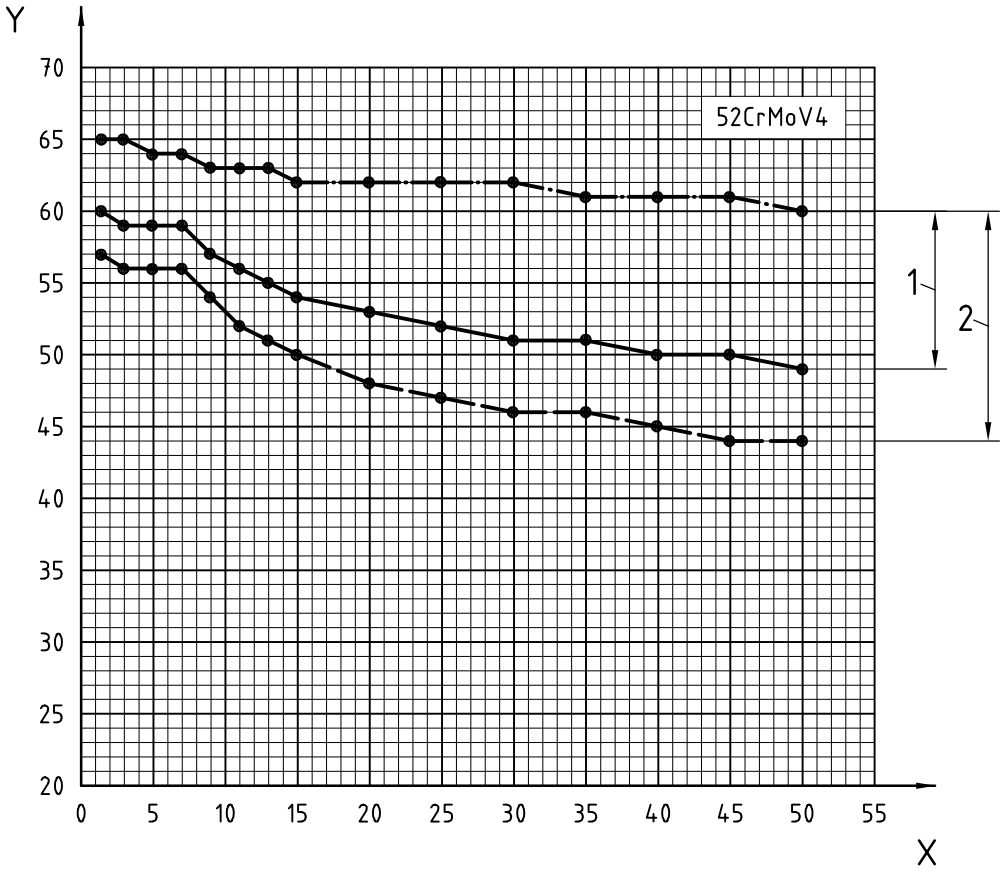
Y Hardness, HRC

1 HH-grade

2 H-grade

Figure 1 — (*continued*)





Key

X Distance from quenched end of test piece, mm

Y Hardness, HRC

1 HH-grade

2 H-grade

Figure 1 — (*continued*)

5 Requirements

5.1 Manufacturing process

5.1.1 Choice of manufacturing process

The manufacturing process for the steel and for the products is, taking into account the restrictions given by the requirements in 5.1.2 to 5.1.4, left to the discretion of the manufacturer.

5.1.2 Deoxidation

All steels shall be fully killed.

5.1.3 Treatment and surface condition on delivery

5.1.3.1 Normal condition on delivery

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

5.1.3.2 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 3, lines 3 to 6.

5.1.3.3 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 1, lines 3 to 6.

5.1.4 Cast separation

The steels shall be delivered separated by casts.

5.2 Chemical composition, hardness and hardenability

5.2.1 Table 3 gives a survey of combinations of usual heat-treatment conditions at delivery as well as product forms and requirements according to Table 2 and Tables 4 to 8 (chemical composition, maximum dimensions for a minimum core hardness, maximum hardness, hardenability).

5.2.2 Where the steel is not ordered according to core hardness or restricted hardenability requirements, i.e. where the steel type designations of Table 2 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 3, (column 5) apply as appropriate, for the particular heat-treatment condition (see footnote c to Table 2).

5.2.3 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 apply, in addition to the requirements cited in Table 3, columns 5 (i) and 5 (ii). In this case, the values of end-quench hardenability given in Table 7 are for guidance purposes only.

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

NOTE 2 For the grades 38Si7+CH and 46Si7+CH maximum dimensions for the minimum core hardness after quenching cannot be delivered.

5.2.4 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 3, columns 5 (i) and 5 (ii).

5.3 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 not only in condition +A but also in condition +S (see Table 3).

5.4 Structure

5.4.1 The steel, when tested in accordance with one of the methods described in ISO 643 shall show an austenitic grain size of 6 or finer. If the verification of the fine grain structure is specified, the method for determination of grain size in accordance with ISO 643 and also the testing conditions shall be agreed upon at the time of enquiry and order.

5.4.2 For the non-metallic inclusion content, see A.1.

5.5 Internal soundness

The steel shall be free from internal defects likely to have an adverse effect (see A.2).

5.6 Surface quality and decarburization

5.6.1 All products shall have a workmanlike finish.

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

In the case of round bars and wire rods, such agreements shall be based on the requirements of ISO 9443.

5.6.3 The values for the admissible partial surface decarburization given in Table 9 apply for the untreated condition and for the treated condition in order to improve shearability as well as for the testing conditions given in 6.2.2.2.

5.6.4 Removal of surface discontinuities by welding is not permitted.

If surface discontinuities are to be removed by other methods, the nature and permissible depth for removal of surface discontinuities shall, where appropriate, be agreed upon at the time of enquiry and order.

5.7 Shape, dimensions and tolerances

The shape, dimensions and tolerances of the products shall comply with the requirements agreed upon at the time of enquiry and order. The agreements shall, as far as possible, be based on corresponding International Standards or otherwise on suitable national standards.

The following International Standards cover dimensions and/or tolerances for products included in this part of ISO 683:

— for flat and round bars: ISO 1035-1, ISO 1035-3 and ISO 1035-4;

— for ribbed and grooved bars: ISO 9442;

— for wire rod: ISO 8457-1.

Table 9 — Admissible partial surface decarburization

Dimensions in millimetres

Type of steel	Flat bars		Round bars		Wire rod	
	Thickness, δ	**Depth of decarburization** max.	**Diameter**, D	**Depth of decarburization** max.	**Diameter**, D	**Depth of decarburization** max.
38Si7 46Si7 60Si8 56SiCr7 61SiCr7 55SiCr6-3 55SiCrV6-3	$5 \leqslant \delta \leqslant 25$	0,01 δ + 0,25[a]	$D \leqslant 10$	0,15	by agreement	
	$25 < \delta$	To be agreed upon	$10 < D$	0,015 D		
55Cr3 60Cr3 60CrMo3-3 51CrV4 52CrMoV4	$5 \leqslant \delta \leqslant 40$	0,01 δ + 0,15[a]	$D \leqslant 10$	0,10	by agreement	
	$40 < \delta$	To be agreed upon	$10 < D$	0,010 D		

[a] These values apply for a width/thickness ratio of $\geqslant 2$. In cases of smaller ratios, the values are to be agreed upon.

6 Inspection, testing and conformity of products

6.1 Inspection and testing procedures and types of inspection documents

6.1.1 For each delivery, the issue of an inspection document in accordance with ISO 10474 may be agreed upon at the time of enquiry and order.

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

a) a statement that the material complies with the requirements of the order;

b) the results of the cast analysis for all elements specified for the steel type supplied.

6.1.3 If, in accordance with the agreements in the order, an inspection certificate 3.1.B or 3.1.C or an inspection report 3.2 (see ISO 10474:1991) is to be provided, the specific inspections and tests described in 6.2 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 (see annex A);

c) the symbol letters or numbers relating the inspection documents, the test pieces and products to each other.

6.2 Specific inspection and testing

6.2.1 Verification of the hardenability and hardness

6.2.1.1 For steels ordered with the designation given in Tables 2, 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 3, column 5 (ii) and the core hardenability according to Table 5 shall be verified.

6.2.1.2 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 listed in Table 10.

6.2.2 Testing of the surface quality and decarburization

6.2.2.1 For round bars and wire rod, the verification of the surface quality shall be in accordance with ISO 9443, unless otherwise agreed. For flat bars, the details of verification are to be agreed upon at the time of enquiry and order.

6.2.2.2 For testing the depth of decarburization, the amount of testing is, unless otherwise agreed, left to the manufacturer. The test is carried out by using the micrographic method described in ISO 3887 and under the following conditions.

— For round products, the measurement starts at the deepest uniformly decarburized 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 decarburized zone, followed by a measurement on the opposite side. The average of these two measurements is then taken.

— Surface discontinuities are excluded from decarburization measurements.

6.2.3 Verification of grain size

In case verification of a fine grain structure is specified, the method for determination of grain size in accordance with ISO 643, the amount of testing and the testing conditions shall be agreed upon at the time of enquiry and order.

6.2.4 Visual and dimensional inspection

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

6.2.5 Retests

In the event of retesting, ISO 404 shall apply.

7 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 10 — Test conditions for the verification of the requirements (see column 2)

1	2		3	4	5	6	7
No.	**Requirements**		**Amount of testing**			**Sampling**[a]	**Test method**
				Number of			
		See Table	Test unit[b]	sample products per test unit	tests per sample product		
1	Chemical composition	2 + 4	C	(The cast analysis is given by the manufacturer; for product analysis, see A.3.)			
2	Hardenability (maximum dimension for a given core hardness)	5	C	1	1	The test piece for evaluation of the core hardenability must have, depending on the required core hardness, the cross-sectional dimensions given in Table 5 for 54 HRC or 56 HRC. 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.	In accordance with ISO 6508-1 (C scales)
3	Hardenability	7 or 8	C	1	1	In cases of dispute, the sampling method given in 5.1 [a) or b1)] of ISO 642:1999 shall be applied, if possible. 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.	In accordance with 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 $1 \times$ thickness 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.	In accordance with ISO 6506-1

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 3, columns 5, 6 or 7.

[a] The general conditions for selection and preparation of test samples and test pieces shall be in accordance with ISO 377 and 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”.

Annex A
(normative)

Supplementary or special requirements

NOTE One or more of the following supplementary or special requirements can be applied but only when specified in the enquiry and order. Details of these requirements shall, where necessary, be agreed upon by the manufacturer and purchaser at the time of enquiry and order.

A.1 Non-metallic inclusion content

The non-metallic inclusion content shall, when microscopically determined according to an agreed procedure (see e.g. ISO 4967), be within agreed limits.

A.2 Ultrasonic tests

The products shall be ultrasonically tested under conditions (and to an acceptance standard) agreed upon at the time of enquiry and order.

A.3 Product analysis

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

The conditions for sampling shall be in accordance with ISO 14284. In cases of dispute, the analysis shall be carried out, if possible, according to the appropriate internationally standardized method.

A.4 Special agreements for marking

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

Annex B
(informative)

Maximum dimensions for flats and rounds based on the 100 % hardenability scatterband

Table B.1 gives, for information, the maximum dimensions for minimum core hardnesses of 54 HRC and 56 HRC. See Table 7 and NOTE 2 in 5.2.3.

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

1	2			3			4	
Type of steel	**Minimum core hardness after quenching**[a] HRC	**Maximum dimensions**[b] for flats (thickness) mm	**Maximum dimensions**[b] for rounds (diameter) mm	**Minimum core hardness after quenching**[c] HRC	**Maximum dimensions**[b] for flats (thickness) mm	**Maximum dimensions**[b] for rounds (diameter) mm	**Heat treatment for verifying the maximum dimensions** Quenching temperature °C	**Heat treatment for verifying the maximum dimensions** Quenching agent
60Si8+CH	54	8	13	56	6	10	830 to 860	Oil
56SiCr7+CH	54	9	15	56	7	11	830 to 860	Oil
61SiCr7+CH	54	12	19	56	10	16	830 to 860	Oil
55SiCr6-3+CH	54	15	24	56	9	14	830 to 860	Oil
55SiCrV6-3+CH	54	17	26	56	9	14	830 to 860	Oil
55Cr3+CH	54	12	19	56	6	10	830 to 860	Oil
60Cr3+CH	54	[d]	[d]	56	[d]	[d]	830 to 860	Oil
60CrMo3-3+CH	54	50	78	56	45	71	830 to 860	Oil
51CrV4+CH	54	12	19	56	6	10	830 to 860	Oil
52CrMoV4+CH	54	16	25	56	12	19	830 to 860	Oil

[a] Larger proportions of bainite are to be expected.
[b] The values are derived from the lower hardenability curve for the full hardenability range (see Table 7).
[c] Small proportions of bainite are to be expected.
[d] Maximum dimensions may be agreed at the time of enquiry and order.

Annex C
(informative)

Guidance values for the mechanical properties of quenched and tempered test pieces

Table C.1 — Guidance values for the mechanical properties of quenched and tempered test pieces

Type of steel	Quench hardening temperature ± 10 °C	Quench hardening medium	Tempering temperature ± 10 °C	$R_{p0,2}$ N/mm^2* min.	R_m N/mm^2 a	A % min.	Z % min.	Impact energy at 20° C KU J min.	Notes
38Si7	—	—	—	—	—	—	—	—	To be agreed upon at the time of enquiry and order
46Si7	—	—	—	—	—	—	—	—	To be agreed upon at the time of enquiry and order
60Si8	860	oil	450	1 300	1 450 to 1 750	6	25	13	Maximum dimensions as given in Table 5.
56SiCr7	860	oil	450	1 350	1 500 to 1 800	6	25	8	Maximum dimensions as given in Table 5.
61SiCr7	860	oil	450	1 400	1 550 to 1 850	5,5	20	8	Maximum dimensions as given in Table 5.
55SiCr6-3	860	oil	450	1 300	1 450 to 1 750	6	25	8	Maximum dimensions as given in Table 5.
55SiCrV6-3	860	oil	400	1 600	1 650 to 1 950	5	35	8	Maximum dimensions as given in Table 5.
55Cr3	840	oil	400	1 250	1 400 to 1 700	3	20	5	Maximum dimensions as given in Table 5.
60Cr3	—	—	—	—	—	—	—	—	To be agreed upon at the time of enquiry and order
60CrMo3-3	860	oil	450	1 300	1 450 to 1 750	6	30	8	Maximum dimensions as given in Table 5.
51CrV4	850	oil	450	1 200	1 350 to 1 650	6	30	8	Maximum dimensions as given in Table 5.
52CrMoV4	860	oil	450	1 300	1 450 to 1 750	6	35	10	Maximum dimensions as given in Table 5.

a 1N/mm^2 = 1 MPa.

Bibliography

[1] ISO 683-1:1987, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Direct-hardening unalloyed and low-alloyed wrought steel in form of different black products*

[2] ISO 4954:1993, *Steels for cold heading and cold extruding*

[3] ISO 4960:1999, *Cold-reduced carbon steel strip with a carbon content over 0,25 %*

[4] ISO 4967:1998, *Steel — Determination of content of nonmetallic inclusions — Micrographic method using standard diagrams*

[5] ISO 8458-3:2002, *Steel wire for mechanical springs — Part 3: Oil-hardened and tempered wire*

[6] ISO 16120-4:2001, *Non-alloy steel wire rod for conversion to wire — Part 4: Specific requirements for wire rod for special applications*

NOTE References [1] [3] [5] and [6] cover steel types which are partly the same as or very similar to those in Table 2, but are destined for other products or treatment conditions or special applications.

ICS 77.140.25

Price based on 22 pages