INTERNATIONAL STANDARD

ISO 683-14

Third edition
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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

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

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.