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

Part 14:

Hot-rolled steels for quenched and tempered
springs
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ISO 683-14:1992
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.

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.

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

This second edition cancels and replaces the first edition (ISO 683-14:1973), of which it constitutes a technical revision.

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 13: *Wrought stainless steels*
- Part 14: *Hot-rolled steels for quenched and tempered springs*
- Part 15: *Valve steels for internal combustion engines*
- Part 16: *Precipitation hardening stainless steels*
- Part 17: *Ball and roller bearing steels*

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

Annex A forms an integral part of this part of ISO 683. Annexes B and C are for information only.

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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 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.

NOTE 1 International Standards relating to steels complying with the chemical composition requirements in table 3, but supplied in product forms or treatment conditions other than those given in 1.1 or intended for special applications, are given in annex C with other related International Standards.

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 this part of ISO 683, the general technical delivery requirements of ISO 404 are applicable.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 683. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 683 are encouraged to investigate the possibility of applying the most recent editions

of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 377-1:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 1: Samples and test pieces for mechanical test.*

ISO 377-2:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 2: Samples for the determination of the chemical composition.*

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

ISO 642:1979, *Steel — Hardenability test by end quenching (Jominy test).*

ISO 643:1983, *Steels — Micrographic determination of the ferritic or austenitic 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 3887:1976, *Steel, non-alloy and low-alloy — Determination of depth of decarburization.*

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

ISO 6506:1981, *Metallic materials — Hardness test — Brinell test.*

ISO 6508:1986, *Metallic materials — Hardness test — Rockwell test (scales A - B - C - D - E - F - G - H - K)*.

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*.

3 Definitions

For the purposes of this part of ISO 683, the following definitions apply.

3.1 product forms: See ISO 6929.

3.2 spring steels: In the sense of this part of ISO 683 steels which are, because of their resilience in the quenched and tempered condition, particularly suitable for the manufacture of springlike 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 increasing carbon contents 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 2) 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 3 and, where appropriate, the symbols for the core hardness grade (see 5.2.3 and table 5) or the restricted hardenability grade (see 5.2.4 and table 8),
 - 3) if a heat-treatment condition other than the untreated condition is required, the symbol for this other condition (see table 1, 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,

according to ISO 1035-1,

with a nominal diameter of 20,0 mm,

with a nominal length of 8 000 mm,

with a diameter tolerance of $\pm 0,25$ mm (= class S of ISO 1035-4),

length tolerance of 0, + 100 mm (= class L2 of ISO 1035-4),

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

Surface

blast cleaned (symbol BC, see table 2).

Steel

according to this part of ISO 683,

type 51 CrV 4 (see table 3),

heat-treatment condition: soft annealed (symbol TA, see table 1),

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—51 CrV 4 TA — 3.1.B.

5 Requirements

5.1 Manufacturing process

5.1.1 Choice of manufacturing process

The manufacturing process for the steel and for the products is, with 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 Heat-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. as 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 1, 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 2, 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 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).

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 3 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 (see footnote 4 to table 3).

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 or table 8 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 are for guidance purposes only.

NOTE 2 — The maximum dimensions given in table 5 correspond to the restricted hardenability scatterband according to table 8. For smaller sizes (see annex B) the normal hardenability scatterband according to table 7 might be sufficient.

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 1, columns 5 (1) and 5 (2).

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 the condition TA but also in condition TS (see table 1).

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 5 and/or finer. The grain structure shall be considered satisfactory if 70 % of the area is within the specified size limits. If the verification of the fine grain structure is specified, the method for determination of grain size according to ISO 643 and 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 should 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 to improve shearability condition and 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 kind and permissible depth for removal of surface discontinuities should, 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.

NOTE 3 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.

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 according to 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) 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 3, 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 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 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, fol-

lowed 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 Visual and dimensional inspection

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

6.2.4 Retests

ISO 404 shall apply for retests.

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 1 — Combinations of usual heat-treatment conditions on delivery, product forms and requirements according to tables 3 to 8

1	2		3	4	5			6			7		
1	Heat treatment condition on delivery	Symbol	Applicable for bars (rounds and flats) and ribbed and grooved bars	wire rod	Applicable requirements								
					ISO 683-14:1992 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	Untreated	None or TU	x	x	—								
3	Treated to improve shearability	TS	x	—	Chemical composition according to tables 3 and 4 (see footnote 4 in table 3)	Maximum Brinell hardness according to table 6	Column TS	Hardness values according to table 7	As in columns 5 (1) and 5 (2)	Restricted hardness values according to table 8	As in columns 5 (1) and 5 (2)	Maximum diameter or thickness for core hardness according to table 5	
4	Soft annealed	TA	x	x			Column TA						
5	Annealed to achieve spheroidization of the carbides	TAC	x	x			Column TAC						
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 and wire rod	
2	Unless otherwise agreed	As hot worked	None or HW	×	×
3	Particular conditions supplied by agreement	HW + pickled	PI	×	×
4		HW + blast cleaned	BC	×	×
5		HW + surface removal ¹⁾	—	×	×
6		Others			

1) 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)

Steel ¹⁾ designation		Comparable type in ISO 683-14:1973	Chemical composition ^{2) 3)} [% (m/m)]								
Number	Name ⁴⁾		C	Si	Mn	P max.	S max.	B min.	Cr	Mo	V
1	59 Si 7	5	0,55 to 0,63	1,60 to 2,00	0,60 to 1,00	0,030	0,030				
2	56 SiCr 7	—	0,52 to 0,59	1,60 to 2,00	0,70 to 1,00	0,030	0,030		0,20 to 0,40		
3	61 SiCr 7	7	0,57 to 0,65	1,60 to 2,00	0,70 to 1,00	0,030	0,030		0,20 to 0,40		
4	55 SiCr 63		0,51 to 0,59	1,20 to 1,60	0,50 to 0,80	0,030	0,030		0,55 to 0,85		
5	55 Cr 3	8	0,52 to 0,59	0,15 to 0,40	0,70 to 1,00	0,030	0,030		0,70 to 1,00		
6	60 CrMo 31	—	0,56 to 0,64	0,15 to 0,40	0,70 to 1,00	0,030	0,030		0,70 to 1,00	0,08 to 0,15	
7	60 CrB 3	10	0,56 to 0,64	0,15 to 0,40	0,70 to 1,00	0,030	0,030	0,000 8 ⁵⁾	0,60 to 0,90		
8	60 CrMo 33	12	0,56 to 0,64	0,15 to 0,40	0,70 to 1,00	0,030	0,030		0,70 to 1,00	0,25 to 0,35	
9	51 CrV 4	13	0,47 to 0,55	0,10 to 0,40	0,60 to 1,00	0,030	0,030		0,80 to 1,10		0,10 to 0,25
10	52 CrMoV 4	14	0,48 to 0,56	0,15 to 0,40	0,70 to 1,00	0,030	0,030		0,90 to 1,20	0,15 to 0,25	0,07 to 0,15

- 1) Unalloyed steels also for the production of springs are covered by the wire rod specification in ISO 8457-2.
- 2) 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 applicability.
- 3) 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 $\pm 0,01$ % (m/m) in the case of carbon, and the values according to table 4 in all other cases.
- 4) These designations are in accordance with ISO 4949.
- 5) Boron contents down to 0,000 5 % (m/m) are tolerated, if the requirements for hardenability are still obtained.

Table 4 — Permissible deviations between specified analysis and product analysis

Element	Permissible maximum content according to cast analysis % (m/m)	Permissible deviation ¹⁾ % (m/m)
C	$\leq 0,55$ $> 0,55 \leq 0,65$	$\pm 0,03$ $\pm 0,04$
Si	$\leq 0,40$ $> 0,40 \leq 2,00$	$\pm 0,03$ $\pm 0,05$
Mn	$\leq 1,00$	$\pm 0,04$
P	$\leq 0,030$	+ 0,005
S	$\leq 0,030$	+ 0,005
B	$\geq 0,000 8$	-- 0,000 3
Cr	$\leq 1,20$	$\pm 0,05$
Mo	$\leq 0,30$ $> 0,30 \leq 0,35$	$\pm 0,03$ $\pm 0,04$
V	$\leq 0,25$	$\pm 0,02$

1) "±" 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.

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

1 Type of steel	2 Minimum core hardness after quenching ¹⁾ HRC	3 Maximum dimensions ²⁾ for		4 Heat treatment for verifying the maximum dimensions
		flats (thickness) mm	rounds (diameter) mm	
59 Si 7 CH	54	11	17	830 to 860 Oil
56 SiCr 7 CH	54	13	20	830 to 860 Oil
61 SiCr 7 CH	54	16	25	830 to 860 Oil
55 SiCr 63 CH	54	20	33	830 to 860 Oil
55 Cr 3 CH	54	14	21	830 to 860 Oil
60 CrMo 3 1 CH	54	33	52	830 to 860 Oil
60 CrB 3 CH	54	29	45	830 to 860 Oil
60 CrMo 3 3 CH	54	55	85	830 to 860 Oil
51 CrV 4 CH	54	25	40	830 to 860 Oil
52 CrMoV 4 CH	54	35	55	830 to 860 Oil

1) Larger proportions of bainite are to be expected.

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

3) Small proportions of bainite are to be expected.