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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

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

Part 11: Wrought case-hardening steels

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

[ISO 683-11:1987](#)

Partie 11: Aciers corroyés pour cémentation

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 683-11 was prepared by Technical Committee ISO/TC 17, *Steel*.

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It cancels and replaces ISO Recommendation R 683-11: 1970, of which it constitutes a technical revision.

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Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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

Part 11 : Wrought case-hardening steels

1 Scope and field of application

1.1 This part of ISO 683 gives the technical delivery requirements for

- semi-finished products, for example blooms, billets, slabs (see note 3),
- bars (see note 3),
- wire rod,
- hot-rolled plates (see note 2), and
- hammer or drop forgings (see note 3),

manufactured from the case-hardening unalloyed or low alloyed steels listed in table 3 and supplied in one of the heat treatment conditions given for the different types of products in table 1, lines 2 to 6, and in one of the surface conditions given in table 2.

The steels are in general intended for the fabrication of case-hardened (see 3.2) machine parts.

NOTES

1 International Standards covering steels complying with the requirements for the chemical composition in table 3, but supplied in other product forms or treatment conditions than given above or intended for special applications, and other related International Standards, are listed in annex B.

2 The term "plate" includes in the following, unless otherwise stated, also wide flats.

3 Hammer-forged semi-finished products (blooms, billets, slabs, etc.) and hammer-forged bars are in the following covered under semi-finished products or bars and not under the term "hammer and drop forgings".

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 inquiry 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 References

ISO 377, *Wrought steel — Selection and preparation of samples and test pieces.*

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

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

ISO 643, *Micrographic determination of the ferritic or austenitic grain size.*

ISO 1035, *Hot-rolled steel bars*

— Part 1: *Dimensions of round bars.*

— Part 2: *Dimensions of square bars.*

— Part 3: *Dimensions of flat bars.*

— Part 4: *Tolerances.*

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

ISO 4954, *Steels for cold heading and cold extruding.*

ISO 4967, *Steel — Determination of content of non-metallic inclusions — Micrographic method using standard diagrams.*

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

ISO 6929, *Definitions of steel products by shape and dimensions.*¹⁾

ISO 7452, *Hot-rolled structural steel plates — Tolerances on dimensions and shape.*

ISO 7788, *Steel — Surface finish of hot-rolled plates and wide flats — Delivery requirements.*

1) At present at the stage of draft.

3 Definitions

For deviations from normal definitions, see notes 2 and 3 to 1.1, and footnote 1 to table 2.

3.1 product forms: See ISO 6929.

3.2 case-hardening steels: In the sense of this part of ISO 683, structural steels with a relatively low carbon content, which are carburized or carbonitrided on their surface and subsequently hardened. These steels, after hardening, have a high degree of hardness in the surface zone and good resistance to wear, whilst the core material is characterized principally by extreme toughness.

NOTE — Further possibilities for heat treatment of case-hardening steels are, for example, nitrocarburizing and nitriding.

3.3 unalloyed and alloyed steel: See ISO 4948/1.

4 Ordering and designation

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

- a) the designation of the product form (bloom, bar, wire rod, etc.) followed by
 - either the designation of the dimensional standard and the dimensions and tolerances selected from it (see 5.7),
 - or, for example in the case of drop forgings, 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 hardenability grade (see 5.2.3 and tables 5 and 6),
 - 3) if a heat treatment condition other than the untreated condition is required, the symbol for this other condition (see table 1, column 3),
 - 4) if a document is required, the symbol for the required type of document (see table 9),
 - 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 40,0 mm,

a nominal length of 8 000 mm,

with a diameter tolerance of $\pm 0,40$ 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 20 MnCr 5 (see table 3),

heat treatment condition: annealed (symbol A, see table 1),

with an inspection certificate of type IC (see table 9) and ultrasonically tested (supplementary requirement specified in clause A.3 in annex A) in accordance with test sheet xy.

Designation

Rounds : ISO 1035/1 – 40,0 S × 8 000 L2

Surface : BC

Steel : ISO 683/11 – 20 MnCr 5 – A – IC – S3

Details : for S3, see test sheet xy

5 Requirements

5.1 Manufacturing process

5.1.1 The manufacturing process of the steel and of 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 at delivery

5.1.3.1 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 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 conditions

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, hardenability and mechanical properties

5.2.1 Table 1 gives a survey on combinations of usual heat-treatment conditions at delivery, product forms and requirements according to tables 3 to 7 (chemical composition, hardenability, maximum hardness, hardness range).

5.2.2 Where the steel is not ordered to hardenability requirements — i.e. where the steel type designations of table 3 and not the designations given in table 5 or 6 are applied — the requirements for chemical composition and hardness cited in table 1, column 9, apply as appropriate for the particular heat-treatment condition. In this case the values of hardenability given in table 5 are for guidance purposes only.

5.2.3 Where the steel is, by using the designations given in table 5 or 6, ordered to normal (see table 5) or to narrowed (see table 6) hardenability requirements, the values of hardenability given in table 5 or 6 respectively apply in addition to the requirements cited in table 1, column 9 (see footnote 2 to table 3).

5.2.4 Mechanical properties for reference test bars in the simulated case-hardened condition are given in table 10 for guidance.

5.3 Technological properties

5.3.1 Machinability

All steels are machinable in the conditions "annealed to maximum hardness requirements" and "treated to improve machinability".

Where improved machinability is required, the grades with a specified sulfur range should be ordered. (See also table 1, line 6.)

5.3.2 Shearability

5.3.2.1 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 shearable in the condition "annealed to maximum hardness requirements".

5.3.2.2 The steel types 20 MnCr 5, 20 MnCrS 5, 15 NiCr 13, 17 NiCrMo 6 and 18 CrNiMo 7, are, under suitable conditions, also shearable when delivered in the condition "treated to improve shearability" with the hardness requirements given in table 7.

5.3.2.3 The unalloyed steels and the steels 20 Cr 4, 20 CrS 4, 16 MnCr 5, 16 MnCrS 5, 18 CrMo 4, 18 CrMoS 4, 20 NiCrMo 2, and 20 NiCrMoS 2 are, under suitable conditions, shearable when delivered in the untreated condition.

5.4 Structure

5.4.1 Unless otherwise agreed, the steel when tested in accordance with one of the methods described in ISO 643 shall show an austenitic grain size of 5 and finer. The grain structure shall be considered satisfactory if 70 % is within the specified size limits. In case 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 at the time of enquiry and order. For coarse grain steel, see annex A, clause A.1.

5.4.2 For the non-metallic inclusion content see annex A, clause A.2.

5.5 Internal soundness

The steel shall be free from internal defects likely to have an adverse effect (see annex A, clause A.3).

5.6 Surface quality

5.6.1 All products shall have a workmanlike finish.

5.6.2 Minor surface discontinuities which may occur under normal manufacturing conditions, such as scores originating in the case of black steel from rolled-in scale, are not to be regarded as defects.

5.6.3 As long as no International Standard on the surface quality of steel products is available, detailed requirements referring to this characteristic shall, where appropriate, be agreed at the time of enquiry and order.

NOTES

- 1 For bars and wire rod included in this part of ISO 683, a separate International Standard on surface quality is in consideration.
- 2 Bars and wire rod for cold heading and cold extrusion are covered fully by ISO 4954.
- 3 It is more difficult to detect and eliminate surface discontinuities from coiled products than from cut lengths. This should be taken into account when agreements on surface quality are made.
- 4 For hot-rolled plates, the requirements for surface finish are specified in ISO 7788.

5.6.4 Removal of surface discontinuities by welding is not permitted.

Pending publication of a separate International Standard, the kind and permissible depth for removal of surface discontinuities should, where appropriate, be agreed 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 at the time of enquiry and order. The agreements shall, as far as possible, be based on corresponding International Standards, otherwise on suitable national standards.

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

- for bars: ISO 1035 parts 1 to 4
- for plates (except for wide flats): ISO 7452 (see note in clause 2).

6 Inspection, testing and conforming of products

6.1 Inspection and testing procedures and types of documents

6.1.1 Table 9 gives a survey of the inspection procedures and the type of documents of ISO 404 which may be agreed at the time of enquiry and order for deliveries according to this part of ISO 683.

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

- a) the statement that the material complies with the requirements of the order and
- 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 (IC or ICP) or an inspection report (IR) (see table 9) 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 results of all inspections and tests ordered by supplementary requirements (see annex A);
- c) the symbol letters or numbers relating the test certificates, the test pieces and products to each other.

6.2 Specific inspection and testing

6.2.1 Verifications of the hardenability and hardness

6.2.1.1 For steels being ordered without hardenability requirements, i.e. without the symbol H, HH or HL in the designation, the hardness requirements given for the relevant heat-treatment condition in table 1, column 9, sub-clause 2, shall be verified.

For steels being ordered with the symbol H, HH or HL in the designation (see table 5 and 6), unless otherwise agreed, only the hardenability requirements according to table 5 or 6 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 prescriptions in table 11.

6.2.2 Visual and dimensional inspection

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

6.2.3 Retests

6.2.3.1 Where for one or more test units one or more tests give unsatisfactory results, the manufacturer has the choice of withdrawing the test units concerned (for example for re-treatment or sorting in accordance with ISO 404) or of retaining them. If they are retained, retests shall be carried out according to the following rules.

6.2.3.2 If — as in the case of product analysis (see annex A, clause A.4) — only one test of the type concerned was carried out on the sample concerned and gave the unsatisfactory result, two new tests of the same type shall be carried out.

6.2.3.3 If the test unit consists of more than one product and if the product from which the unsatisfactory test result stems is not withdrawn from the test unit, one of the two new tests shall be made on test pieces taken from the sample or product originally tested.

6.2.3.4 All retests shall give satisfactory results. Otherwise the test unit concerned shall be rejected.

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 annex A, clause A.5).

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Table 1 — Combinations of usual heat-treatment conditions at delivery, product forms and requirements according to tables 3 to 6

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1	2	3	4					5			6			9	10			11	
			semi-finished products	bars	wire rod	plates	hammer and drop forgings	None or U	S	A	M	table 3	table 3		table 3	table 5 or 6	table 5 or 6		table 5 or 6
1	Heat-treatment condition at delivery	Symbol	Applicable for					Applicable for			Applicable requirements if the steel is ordered with the designation given in			Remarks					
2	Untreated	None or U	x	x	x	x	x	x	x	x	1.	2.	3.	1.	2.	3.	Observe also the supplementary requirements given in annex A.		
3	Treated to improve shearability	S	x	x	—	—	—	—	—	—	Chemical composition according to tables 3 + 4	Maximum Brinell hardness according to table 7	Column S	As in column 9 (see footnote 2 to table 3)	Hardenability values according to table 5 or 6				
4	Annealed to maximum hardness requirements	A	x	x	x	x	x	x	x	x	Column A	Column M							
5	Treated to improve machinability	M	—	x	x	x	x	x	x	x									
6	Others		Other treatment conditions, for example certain annealing conditions to achieve a certain structure, may be agreed at the time of enquiry and order. The condition "annealed to achieve a spheroidization of the carbides", as required for cold heading and cold extrusion, is covered in ISO 4954.																

Table 2 – Surface condition at delivery

1	2		3	4	5	6	7	8	9	10
1	Surface condition at delivery		Symbol	x = In general applicable for						Notes
				semi-finished products such as blooms, billets	bars	wire rods	plates	hammer and drop forgings (see 1.1, note 3)		
2	Unless otherwise agreed	As hot worked	None or HW	x ¹⁾	x	x	x	x	x	
3	Particular conditions supplied by agreement	HW + pickled	P1	x	x	x	x	x	x	3)
4		HW + blast cleaned	BC	x	x	x	x	x	x	
5		HW + rough machined	2)	x	x	x	x	x	x	
6		Others								

1) The term "hot worked" includes in the case of semi-finished products also the continuously cast condition.

2) Until the term "rough machined" is defined by, for example, machining allowances etc., the details are to be agreed at the time of enquiry and order.

3) In addition it may be agreed that the products are oiled or, where appropriate, limed or phosphated.

Table 3 – Types of steel and chemical composition (applicable to cast analysis) 1), 2), 3), 4)

Type of steel ⁵⁾		C %	Si % ⁶⁾	Mn %	P % max.	S %	Cr %	Mo %	Ni %
C 10	1	0,07 to 0,13	0,15 to 0,40	0,30 to 0,60	0,035	0,035 max.	—	—	—
C 15 E4 C 15 M2	2 2a	0,12 to 0,18	0,15 to 0,40	0,30 to 0,60	0,035	0,035 max. 0,020 to 0,040	—	—	—
C 16 E4 C 16 M2	3 3a	0,12 to 0,18	0,15 to 0,40	0,60 to 0,90	0,035	0,035 max. 0,020 to 0,040	—	—	—
20 Cr 4 20 CrS 4	(4)	0,17 to 0,23	0,15 to 0,40	0,60 to 0,90	0,035	0,035 max. 0,020 to 0,040	0,90 to 1,20	—	—
16 MnCr 5 16 MnCrS 5	5 5a	0,13 to 0,19	0,15 to 0,40	1,00 to 1,30	0,035	0,035 max. 0,020 to 0,040	0,80 to 1,10	—	—
20 MnCr 5 20 MnCrS 5		0,17 to 0,23	0,15 to 0,40	1,10 to 1,40	0,035	0,035 max. 0,020 to 0,040	1,00 to 1,30	—	—
18 CrMo 4 18 CrMoS 4	7 7a	0,15 to 0,21	0,15 to 0,40	0,60 to 0,90	0,035	0,035 max. 0,020 to 0,040	0,90 to 1,20	0,15 to 0,25	—
15 NiCr 13	(11)	0,12 to 0,18	0,15 to 0,40	0,35 to 0,65	0,035	0,035 max.	0,60 to 0,90	—	3,00 to 3,50
20 NiCrMo 2 20 NiCrMoS 2	12 12a	0,17 to 0,23	0,15 to 0,40	0,65 to 0,95	0,035	0,035 max. 0,020 to 0,040	0,30 to 0,65	0,15 to 0,25	0,40 to 0,70
17 NiCrMo 6	13	0,14 to 0,20	0,15 to 0,40	0,60 to 0,90	0,035	0,035 max.	0,80 to 1,10	0,15 to 0,25	1,20 to 1,60
18 CrNiMo 7		0,15 to 0,21	0,15 to 0,40	0,35 to 0,65	0,035	0,035 max.	1,50 to 1,80	0,25 to 0,35	1,40 to 1,70

1) Elements not quoted in this table 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 materials used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

2) In the case of grades with specified hardenability requirements (see tables 5 and 6), except for phosphorus and sulfur, insignificant deviations from the limits for cast analysis are permissible; these deviations shall, however, not exceed in the case of carbon $\pm 0,01$ % and in all other cases the values according to table 4.

3) Steels with improved machinability by either lead additions or controlled sulfide morphology may be available on request.

4) Additional case-hardening steels, predominantly used for bearings, are covered by ISO 683/17.

5) The designations given in the first column are in accordance with the system proposed by ISO/TC 17/SC 2. The number in the second column represent the antiquated numbers of ISO/R 683/11-1970.

6) A lower silicon content may be agreed at the time of enquiry and order; in this case the influence on mechanical properties should be taken into account.

Table 4 – Permissible deviations between specified analysis and product analysis

Element	Permissible maximum content according to cast analysis % (m/m)	Permissible deviations ¹⁾ % (m/m)
C	< 0,23	± 0,02
Si	< 0,40	± 0,03
Mn	< 1,00 > 1,00 < 1,40	± 0,04 ± 0,06
P	< 0,035	± 0,005
S	< 0,040	+ 0,005 ²⁾
Cr	< 1,80	± 0,05
Mo	< 0,30 > 0,30 < 0,35	± 0,03 ± 0,04
Ni	< 1,00 > 1,00 < 2,00 > 2,00 < 3,50	± 0,03 ± 0,05 ± 0,07

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.

2) For steels with a specified sulfur range (0,020 to 0,040 % according to cast analysis), the permissible deviation is ± 0,005 %.

Table 5 — Hardness limits for steel types with specified (normal) hardenability (H-grades; see 5.2)

Type of steel	Limits of range	Hardness HRC at a distance from quenched end of test piece (in millimetres) of												
		1.5	3	5	7	9	11	13	15	20	25	30	35	40
20 Cr 4 H	max.	49	48	46	42	38	36	34	32	29	27	26	24	23
20 CrS 4 H	min.	41	38	31	26	23	21	—	—	—	—	—	—	—
16 MnCr 5 H	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
16 MnCrS 5 H	min.	39	36	31	28	24	21	—	—	—	—	—	—	—
20 MnCr 5 H	max.	49	49	48	46	43	42	41	39	37	35	34	33	32
20 MnCrS 5 H	min.	41	39	36	33	30	28	26	25	23	21	—	—	—
18 CrMo 4 H	max.	47	46	45	42	39	37	35	34	31	29	28	27	26
18 CrMoS 4 H	min.	39	37	34	30	27	24	22	21	—	—	—	—	—
15 NiCr 13 H	max.	46	46	46	46	45	44	43	41	38	35	34	34	33
	min.	38	37	36	34	31	29	27	26	24	22	22	21	21
20 NiCrMo 2 H	max.	49	48	45	42	36	33	31	30	27	25	24	24	23
20 NiCrMoS 2 H	min.	41	37	31	25	22	20	—	—	—	—	—	—	—
17 NiCrMo 6 H	max.	48	48	47	46	45	44	42	41	38	36	35	34	33
	min.	40	39	37	34	30	28	27	26	24	23	22	21	—
18 CrNiMo 7 H	max.	48	48	48	48	47	47	46	46	44	43	42	41	41
	min.	40	40	39	38	37	36	35	34	32	31	30	29	29