INTERNATIONAL STANDARD

ISO 683-17

Third edition
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Heat-treated steels, alloy steels and free-cutting steels —

Part 17: Ball and roller bearing steels

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

Partie 17: Aciers pour roulements

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 4, *Heat treatable and alloy steels*.

This third edition cancels and replaces the second edition (ISO 683-17:1999), which has been technically revised.

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

— *Part 1: Non-alloy steels for quenching and tempering*

— *Part 2: Alloy steels for quenching and tempering*

— *Part 3: Case-hardening steels*

— *Part 4: Free-cutting steels*

— *Part 5: Nitriding 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 steel products*

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

Part 17:
Ball and roller bearing steels

1 Scope

1.1 This part of ISO 683 specifies the technical delivery requirements for five groups of wrought ball and roller bearing steels as listed in Table 3, namely

— through-hardening bearing steels (steels with about 1 % C and 1 % to 2 % Cr),

— case-hardening bearing steels,

— induction-hardening bearing steels (unalloyed and alloyed),

— stainless bearing steels, and

— high-temperature bearing steels.

1.2 This part of ISO 683 applies to the products and heat-treatment conditions given in Table 1 and the surface conditions given in Table 2.

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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

ISO 3763, *Wrought steels — Macroscopic methods for assessing the content of non-metallic inclusions*

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

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

ISO 4948-2, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*

ISO/TS 4949, *Steel names based on letter symbols*

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

ISO 4969, *Steel — Macroscopic examination by etching with strong mineral acids*

ISO 5949, *Tool steels and bearing steels — Micrographic method for assessing the distribution of carbides using reference photomicrographs*

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

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 6929, *Steel products — Vocabulary*

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

ISO/TR 9769, *Steel and iron — Review of available methods of analysis*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6929 and the following apply.

3.1
ball and roller bearing steels
steels for rings and/or rolling bodies which use balls and rollers to maintain the separation between the moving parts of the bearing

4 Classification and designation

4.1 Classification

The classification of the relevant steel grades is allocated in accordance with ISO 4948-1 and ISO 4948-2. All steel grades covered by this part of ISO 683 are special steels.

4.2 Designation

For the steel grades covered by this part of ISO 683, the steel names given in the relevant tables are allocated in accordance with ISO/TS 4949.

5 Information to be supplied by the purchaser

5.1 Mandatory information

The manufacturer shall obtain the following information from the purchaser at the time of enquiry and order:

a) the quantity to be delivered;

b) the designation of the products form (billets, bars, rod, wire, tubes, rings, discs, etc.);

c) either the reference to the dimensional standard and the dimensions and tolerances selected from it (see 7.6) or the designation of any other document covering the dimensions and tolerances required for the product;

d) a reference to this part of ISO 683, i.e ISO 683-17;

e) the designation of the steel grade (see Table 3);

f) the symbol for the heat-treatment condition on delivery (see 6.3.1 and Table 1);

g) usually designation for an inspection certificate 3.1 or, if required, an inspection certificate 3.2 in accordance with ISO 10474.

5.2 Options/Supplementary or special requirements

A number of options are specified in this part of ISO 683 and listed below. If the purchaser does not indicate the wish to implement any of theses options, the products will be supplied in accordance with the basic specifications of this part of ISO 683 (see 5.1).

a) If another surface condition than 'hot-worked' or a special surface quality is required, the surface condition (see Table 2), and the surface quality (see 7.5).

b) Any requirement concerning the hardenability (+H) (see 7.1.3 and Table 5) and the verification of hardenability and if agreed the information about calculation of the hardenability (see 9.2.2).

c) Any supplementary requirement that shall be complied with, the symbol and, where necessary, the details of this supplementary requirement (see Annex A).

EXAMPLE 50 hot-rolled round bars according to ISO 1035-1 with nominal diameter of 50,0 mm, nominal length of 8 000 mm and with tolerance class S on diameter of ± 0,40 mm and tolerance class L2 on length of +100/0 mm in accordance with ISO 1035-4 and with hot-worked surface made of steel grade ISO 683-17, 100Cr6 (see Table 3) in annealed condition to achieve spheroidized carbides (+AC), with an inspection certificate 3.1 in accordance with ISO 10474:

50 round bars ISO 1035-1/-4 – 50,0 S × 8 000 L2

steel grade ISO 683-17 - 100Cr6+AC

inspection certificate ISO 10474 - 3.1

6 Manufacturing process

6.1 General

With the restrictions given by the requirements in 6.2 and 6.3 the manufacturing process of the steel and of the products is left to the discretions of the manufacturer.

If requested, the purchaser shall be informed about the steel making process used.

Remelting of the steel may be agreed upon at the time of enquiry and order.

6.2 Deoxidation

All steels shall be deoxidized.

6.3 Heat treatment and surface condition at delivery

6.3.1 Heat-treatment condition

The products shall be delivered in one of the heat-treatment conditions given in Table 1, lines 2 to 10, as agreed at the time of enquiry and order. If there is no agreement, the products shall be delivered in the untreated condition.

6.3.2 Particular surface conditions

If agreed upon 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 9.

6.3.3 Traceability of the cast

Each product shall be traceable to the cast, see Clause 10.

7 Requirements

7.1 Chemical composition and hardenability

7.1.1 General

Table 1 gives a survey of combinations of usual heat-treatment conditions at delivery, product forms and requirements according to Tables 3 to 6 (chemical composition, hardenability, maximum hardness, hardness range).

7.1.2 Chemical composition

The chemical composition determined by cast analysis shall comply with the values in Table 3.

Permissible deviations between the limiting values for cast analysis and the values for product analysis are given in Table 4.

The product analysis shall be carried out when specified at the time of the enquiry and order (see 9.1 and A.2).

7.1.3 Hardenability

Where the steel is not ordered according to hardenability requirements, i.e. where the steel type designations of Table 3 and not the designations given in Table 5 are applied, the requirements for hardness specified in Table 6 (see also 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.

Where the steel is ordered to hardenability requirements by using the designations given in Table 5 the values of hardenability given in Table 5 apply in addition to the requirements cited in Table 1, column 9 (see footnote b to Table 3).

7.1.4 Hardness

The hardness in the usual conditions of delivery is given in Table 6.

7.2 Microstructure

7.2.1 Austenitic grain size of case-hardening and induction-hardening bearing steels

Case-hardening steels and induction-hardening steels shall have a fine grain size of 5 or finer (see ISO 643). For verification of the grain size, see A.3.

7.2.2 Spheroidization and distribution of carbides

7.2.2.1 For deliveries in treatment conditions +AC and +AC+C, the carbides of the through-hardening steels shall be spheroidized and the carbides of the stainless and high-temperature bearing steels shall

be predominantly spheroidized. Case-hardening steels may show remnants of incompletely spheroidized carbides. For the degree of spheroidization see A.4.

7.2.2.2 For distribution of carbides, see A.5.

7.2.3 Structure of case-hardening steels in the condition +FP

The structure shall consist of ferrite-pearlite. Bainite contents up to 10 % are, however, permissible.

7.3 Non-metallic inclusions

7.3.1 Microscopic inclusions

The characterization of non-metallic inclusions is critically important to the fatigue life of bearings. Therefore all bearing steels shall have a certain degree of cleanliness. The requirements for the content of non-metallic inclusions apply in every case; however, verification requires a special agreement, see A.6.

7.3.2 Macroscopic inclusions

If verification is agreed then the method and acceptance limits shall be agreed at the time of enquiry and order.

7.4 Internal soundness

Where appropriate, requirements relating to the internal soundness of the products shall be agreed at the time of enquiry and order, see A.7.

7.5 Surface quality

7.5.1 All products shall have a smooth surface finish appropriate to the manufacturing process applied.

7.5.2 Ground or peeled/turned or machined products shall be free from surface discontinuities detrimental to practical use and surface decarburization.

7.5.3 If hot-rolled, forged, cold-reduced or rough-machined products are ordered for peeling or grinding to avoid

a) surface decarburization, and

b) surface defects

the machining allowances shall be agreed upon at the time of enquiry and order.

Alternatively, for round bars and rod, the permissible depth of surface discontinuities may be specified in accordance with ISO 9443.

7.6 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 (see Annex C) or, otherwise, on suitable national standards.

8 Inspection

8.1 Testing procedures and types of inspection documents

8.1.1 Products complying with this part of ISO 683 shall be ordered and delivered with inspection certificate 3.1 or 3.2 as specified in ISO 10474. The type of document shall be agreed upon at the time of enquiry and order. If the order does not contain any specification of this type, an inspection certificate 3.1 shall be issued.

8.1.2 The specific inspections and tests described in 8.2 and 8.3 shall be carried out and the results shall be confirmed in the inspection certificate.

In addition the inspection certificate report shall cover:

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

b) results of the cast analysis for all elements specified in Table 3 for the steel grade concerned;

c) the results of all inspections and tests ordered by supplementary requirements (see Annex A);

d) the symbol letters or numbers connecting the inspection document with the relevant test unit.

8.2 Frequency of testing

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 7.

8.3 Specific inspection and testing

8.3.1 Verification of the hardenability and hardness

The hardness requirements given for the relevant heat-treatment condition in Table 6 (see also Table 1, column 9, sub-column 9.2) shall be verified.

For steels ordered with the symbol +H in the designation (see Table 5), in addition, the hardenability requirements according to Table 5 shall be verified.

8.3.2 Inspection of the surface quality

Unless otherwise agreed at the time of enquiry and order (see A.8), the extend of testing and the test method is left to the discretion of the manufacturer.

8.3.3 Dimensional inspection

Unless otherwise agreed at the time of enquiry and order (see A.9), the number of products to be inspected for their shape and dimensions shall be left to the discretion of the manufacturer.

9 Test methods

9.1 Chemical analysis

The choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. In cases of dispute, the method for product analysis used shall be agreed, taking into account the relevant existing International Standards.

NOTE The list of available International Standards on chemical analysis is given in ISO/TR 9769.

9.2 Hardness and hardenability tests

9.2.1 Hardness

For products in treatment conditions +S, +A, +TH, +AC, +AC+C and +FP (see Table 6), the hardness shall be measured in accordance with ISO 6506-1.

9.2.2 Verification of hardenability

As far as available, the manufacturer has the option to verify the hardenability by calculation. The calculation method is left to the discretion of the manufacturer. If agreed at the time of enquiry and order the manufacturer shall give sufficient information about the calculation for the customer to confirm the result.

If a calculation formula is not available or in the case of dispute, an end-quench hardenability test shall be carried out in accordance with ISO 642. The temperature for quenching shall comply with Table 5. The hardness values shall be determined in accordance with ISO 6508-1, scale C.

9.2.3 Retests

For retests, ISO 404 shall apply.

10 Marking

The manufacturer shall mark the products or the bundles or boxes containing the products in a suitable way, so that identification of the cast, the steel grade and the origin of the delivery is possible (see A.10).

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

	1	2	3	4	5	6	7	8	9			10		
1	Heat-treatment condition at delivery	Symbol	X = Applicable for						Applicable requirements if the steel is ordered with the designation given in					
									Tables 3, 4 and 6			Table 5		
			billets	bars	wire rod	wire	tube	rings and discs	9.1	9.2		10.1	10.2	10.3
2	Untreated	None or +U	x	x	x	–	–	–	Chemical composition according to Tables 3 and 4	-				
3	Treated for cold shearability	+S	x	x	x	–	–	–		Maximum hardness or hard-ness range accor-ding to Table 6	Column +S	As in column 9.1 and 9.2 (see footnote b to Table 3)		Hardenability values according to Table 5
4	Soft annealed/solution annealed	+A/+AT	–	x	x	–	–	–			Column +A			
5	Treated to hardness range	+TH	–	x	x	x	-	x			Column +TH			
6	Annealed to achieve spheroidized carbides	+AC	–	x	x	x	x	x			Column +AC			
7	Annealed to achieve spheroidized carbides and cold-worked	+AC+C	–	x	–	x	x	x			Column +AC+C			
8	Isothermically treated to ferrite-perlite structure and hardness range	+FP	–	x	x	–	x	x			Column +FP			
9	Stress relieved	+SR	–	–	–	x	x	–			–			
10	Others	Other treatment conditions, e.g. the quenched and tempered condition, may be agreed at the time of enquiry and order.												

Table 2 — Surface condition at delivery

	1	2	3	4	5	6	7	8	9
1	Surface condition at delivery		Symbol	x = In general applicable for					
				billets	bars	**wire rod**[a]	**wire**[a]	tubes	rings and discs
2	Unless otherwise agreed	As-hot-worked	None or +HW	x	x	x	–	x	x
3	Particular conditions supplied by agreement	Machined	+MA	–	x	–	–	–	x
4		Peeled/turned	+SH	–	x	x	–	x	–
5		Ground	+G	–	x	–	–	–	–
6		Cold drawn	+C	–	x	–	x	x	–
7		Cold pilgered (rocked)	+CP	–	–	–	–	x	–
8		Cold rolled	+CR	–	–	–	–	–	x
9		Others	–	–	x	x	x	x	x

[a] Cold drawn rod is by definition wire (see ISO 6929).

Table 3 — Steel grades and chemical composition (cast analysis)

Steel designation	% [mass fraction] [a, b]										
Name	C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Others
Through-hardening bearing steels											
100Cr6	0,93 to 1,05[c]	0,15 to 0,35[d]	0,25 to 0,45	0,025	0,015[e]	1,35 to 1,60	0,10	–	–	–	Al: 0,050 Ca: [f] Cu: 0,30 O: 0,0015[g] Ti:[h]
100CrMnSi4–4	0,93 to 1,05[c]	0,45 to 0,75	0,90 to 1,20	0,025	0,015[e]	0,90 to 1,20	0,10	–	–	–	
100CrMnSi6–4	0,93 to 1,05[c]	0,45 to 0,75	1,00 to 1,20	0,025	0,015[e]	1,40 to 1,65	0,10	–	–	–	
100CrMnSi6–6	0,93 to 1,05[c]	0,45 to 0,75	1,40 to 1,70	0,025	0,015[e]	1,40 to 1,65	0,10	–	–	–	
100CrMo7	0,93 to 1,05[c]	0,15 to 0,45	0,25 to 0,45	0,025	0,015[e]	1,65 to 1,95	0,15 to 0,30	–	–	–	
100CrMo7–3	0,93 to 1,05[c]	0,15 to 0,45	0,60 to 0,80	0,025	0,015[e]	1,65 to 1,95	0,20 to 0,35	–	–	–	
100CrMo7–4	0,93 to 1,05[c]	0,15 to 0,35	0,60 to 0,80	0,025	0,015[e]	1,65 to 1,95	0,40 to 0,50	–	–	–	
100CrMnMoSi8–4-6	0,93 to 1,05[c]	0,40 to 0,60	0,80 to 1,10	0,025	0,015[e]	1,80 to 2,05	0,50 to 0,60	–	–	–	
Case-hardening bearing steels											
20Cr3	0,17 to 0,23	0,40	0,60 to 1,00	0,025	0,015[e]	0,60 to 1,00	–	–	–	–	Al: 0,050 Ca: [f] Cu: 0,30 O: 0,0020[g] Ti:[h]
20Cr4	0,17 to 0,23	0,40	0,60 to 0,90	0,025	0,015[e]	0,90 to 1,20	–	–	–	–	
20MnCr4–2	0,17 to 0,23	0,40	0,65 to 1,10	0,025	0,015[e]	0,40 to 0,75	–	–	–	–	
17MnCr5	0,14 to 0,19	0,40	1,00 to 1,30	0,025	0,015[e]	0,80 to 1,10	–	–	–	–	
19MnCr5	0,17 to 0,22	0,40	1,10 to 1,40	0,025	0,015[e]	1,00 to 1,30	–	–	–	–	
15CrMo4	0,12 to 0,18	0,40	0,60 to 0,90	0,025	0,015[e]	0,90 to 1,20	0,15 to 0,25	–	–	–	
20CrMo4	0,17 to 0,23	0,40	0,60 to 0,90	0,025	0,015[e]	0,90 to 1,20	0,15 to 0,25	–	–	–	
20MnCrMo4–2	0,17 to 0,23	0,40	0,65 to 1,10	0,025	0,015[e]	0,40 to 0,75	0,10 to 0,20	–	–	–	
20MnNiCrMo3–2	0,17 to 0,23	0,40	0,60 to 0,95	0,025	0,015[e]	0,35 to 0,70	0,15 to 0,25	0,40 to 0,70	–	–	
20NiCrMo7	0,17 to 0,23	0,40	0,40 to 0,70	0,025	0,015[e]	0,35 to 0,65	0,20 to 0,30	1,60 to 2,00	–	–	
18CrNiMo7–6	0,15 to 0,21	0,40	0,50 to 0,90	0,025	0,015[e]	1,50 to 1,80	0,25 to 0,35	1,40 to 1,70	–	–	
18NiCrMo14–6	0,15 to 0,20	0,40	0,40 to 0,70	0,025	0,015[e]	1,30 to 1,60	0,15 to 0,25	3,25 to 3,75	–	–	
16NiCrMo16–5	0,14 to 0,18	0,40	0,25 to 0,55	0,025	0,015[e]	1,00 to 1,40	0,20 to 0,30	3,80 to 4,3	–	–	

Table 3 — *(continued)*

Steel designation	**% [mass fraction]** [a, b]										
Name	C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Others
Induction-hardening bearing steels											
C56E2	0,52 to 0,60	0,40	0,60 to 0,90	0,025	0,015[e]	–	–	–	–	–	Al: 0,050
56Mn4	0,52 to 0,60	0,40	0,90 to 1,20	0,025	0,015[e]	–	–	–	–	–	Ca: [f], Cu: 0,30
70Mn4	0,65 to 0,75	0,40	0,80 to 1,10	0,025	0,015[e]	–	–	–	–	–	O: 0,0020[g]
43CrMo4	0,40 to 0,46	0,40	0,60 to 0,90	0,025	0,015[e]	0,90 to 1,20	0,15 to 0,30	–	–	–	Ti: [h]
Stainless bearing steels											
X47Cr14	0,43 to 0,50	1,00	1,00	0,040	0,015[e]	12,5 to 14,5	–	–	–	–	–
X65Cr14	0,60 to 0,70	1,00	1,00	0,040	0,015[e]	12,5 to 14,5	0,75	–	–	–	–
X108CrMo17	0,95 to 1,20	1,00	1,00	0,040	0,015[e]	16,0 to 18,0	0,40 to 0,80	–	–	–	–
X40CrMoVN16–2	0,37 to 0,45	0,60	0,60	0,025	0,015[e]	15,0 to 16,5	1,50 to 1,90	0,30	0,20 to 0,40	–	N: 0,16 to 0,25
X89CrMoV18–1	0,85 to 0,95	1,00	1,00	0,040	0,015[e]	17,0 to 19,0	0,90 to 1,30	–	0,07 to 0,12	–	–

Table 3 — *(continued)*

Steel designation Name	% [mass fraction] [a, b] C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Others
High-temperature bearing steels											
33CrMoV12–9	0,29 to 0,36	0,10 to 0,40	0,40 to 0,70	0,025	0,015	2,80 to 3,30	0,70 to 1,20	0,30	0,15 to 0,25	–	Cu: 0,10
80MoCrV42–16	0,77 to 0,85	0,40	0,15 to 0,35	0,025[i]	0,015[i]	3,9 to 4,3	4,0 to 4,5	–	0,90 to 1,10	0,25	Cu: 0,30
13MoCrNi42–16–14	0,10 to 0,15	0,10 to 0,25	0,15 to 0,35	0,015	0,010	3,9 to 4,3	4,0 to 4,5	3,20 to 3,60	1,00 to 1,30	0,15	Cu: 0,10[k]
X82WMoCrV6–5-4	0,78 to 0,86	0,40	0,40	0,025	0,015	3,9 to 4,3	4,7 to 5,2	–	1,70 to 2,00	6,0 to 6,7	Cu: 0,30
X75WCrV18–4-1	0,70 to 0,80	0,40	0,40	0,025	0,015	3,9 to 4,3	0,60	–	1,00 to 1,25	17,5 to 19,0	Cu: 0,30

Elements not quoted shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions should be taken to prevent additions from scrap or other materials, used in the manufacture of such elements, which affect the hardenability, mechanical properties and applicability.

[a] Maximum values unless otherwise indicated.

[b] In the case of the grades with specified hardenability requirements (see Table 5), except for phosphorus and sulfur, insignificant deviations from the limits for cast analysis are permissible; these deviations shall, however, not exceed ± 0,01 % in the case of carbon and in all other cases the values according to Table 4.

[c] Minimum limits lower than 0,93 % C or maximum limits higher than 1,05 % C may be agreed upon at the time of enquiry and order.

[d] By agreement max. 0,15 % Si for cold forming.

[e] Where machinability is of primary importance, max. 0,030 % sulfur may be agreed at the time of enquiry and order.

[f] Intentional additions of calcium or calcium alloys for deoxidation or inclusion shape control are not permitted unless specifically approved by the purchaser.

[g] The oxygen content applies to cast analysis or product analysis at the discretion of the manufacturer.

[h] A maximum titanium content may be agreed upon at the time of enquiry and order.

[i] Max. 0,015 % phosphorus and max. 0,008 % sulfur may be agreed upon at the time of enquiry and order.

[k] Max. 0,20 % Cu may be agreed upon at the time of enquiry and order.

Table 4 — Permissible deviations between the product analysis and the limiting values given in Table 3 for the cast analysis

Element	Permissible maximum content according to cast analysis % (mass fraction)	Permissible deviation[a], for all bearing steels % (mass fraction)
C	C ≤ 0,60	±0,02
	0,60 < C ≤ 1,20	±0,03
Si	Si ≤ 0,40	±0,03
	0,40 < Si ≤ 1,00	±0,05
Mn	Mn ≤ 1,00	±0,04[b]
	1,00 < Mn ≤ 1,40	±0,06
P	*P* ≤ 0,040	+ 0,005
S	S ≤ 0,025	+ 0,005
Cr	Cr ≤ 2,00	±0,05
	2,00 < Cr ≤ 10,0	±0,10
	10,0 < Cr ≤ 15,0	±0,15
	15,0 < Cr ≤ 19,0	±0,20
Mo	Mo ≤ 0,30	±0,03
	0,30 < Mo ≤ 0,60	±0,05[c]
	0,60 < Mo ≤ 1,75	±0,07
	1,75 < Mo ≤ 5,2	±0,10
Ni	Ni ≤ 1,00	±0,03
	1,00 < Ni ≤ 2,00	±0,05
	2,00 < Ni ≤ 4,3	±0,07
V	V ≤ 0,50	±0,03
	0,50 < V ≤ 1,50	±0,05
	1,50 < V ≤ 2,00	±0,10
W	W ≤ 0,25	±0,03
	5,0 < W ≤ 10,0	±0,10
	10,0 < W ≤ 19,0	±0,20
Al	Al ≤ 0,050	+ 0,010
Cu	Cu ≤ 0,30	+ 0,03

[a] ± means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in Table 3, but not both at the same time.

[b] For stainless bearing steels: Mn +0,03 %.

[c] For high-temperature bearing steels: Mo +0,03 %.

Table 5 — Hardness limits for case-hardening and induction-hardening steels (+H-grades) in the end-quench hardenability test

Steel designation	Limits of range	Hardness HRC at a distance, in millimetres, from quenched end of test piece															Quenching temperature
Name		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50	°C
20Cr3+H	max.	48	46	41	34	31	29	27	25	22	–	–	–	–	–	–	900 ± 5
	min.	40	34	27	22	20	–	–	–	–	–	–	–	–	–	–	
20Cr4+H	max.	49	48	46	42	38	36	34	32	29	27	26	24	23	–	–	900 ± 5
	min.	41	38	31	26	23	21	–	–	–	–	–	–	–	–	–	
20MnCr4–2+H	max.	49	48	46	42	39	37	34	33	32	30	28	26	24	–	–	900 ± 5
	min.	41	38	31	28	24	21	–	–	–	–	–	–	–	–	–	
17MnCr5+H	max.	47	46	44	41	39	37	35	33	31	30	29	28	27	–	–	900 ± 5
	min.	39	36	31	28	24	21	–	–	–	–	–	–	–	–	–	
19MnCr5+H	max.	49	49	48	46	43	42	41	39	37	35	34	33	32	–	–	900 ± 5
	min.	41	39	36	33	30	28	26	25	23	21	–	–	–	–	–	
15CrMo4+H	max.	46	45	41	38	34	31	29	28	26	25	24	24	23	23	22	900 ± 5
	min.	39	36	29	24	21	20	–	–	–	–	–	–	–	–	–	
20CrMo4+H	max.	48	48	47	44	41	39	37	35	33	31	30	30	29	29	28	900 ± 5
	min.	40	39	35	31	28	25	24	23	20	20	–	–	–	–	–	
20MnCrMo4–2+H	max.	48	46	40	34	29	27	25	24	21	–	–	–	–	–	–	900 ± 5
	min.	41	37	27	22	–	–	–	–	–	–	–	–	–	–	–	
20MnNiCrMo3–2+H	max.	49	48	45	42	36	33	31	30	27	25	24	24	23	–	–	900 ± 5
	min.	41	37	31	25	22	20	–	–	–	–	–	–	–	–	–	
20NiCrMo7+H	max.	48	47	45	42	39	36	34	32	29	26	25	24	24	24	24	900 ± 5
	min.	40	38	34	30	27	25	23	22	20	–	–	–	–	–	–	
18CrNiMo7–6+H	max.	48	48	48	48	47	47	46	46	44	43	42	41	41	–	–	860 ± 5
	min.	40	40	39	38	37	36	35	34	32	31	30	29	29	–	–	

Table 5 — *(continued)*

Steel designation	Limits of range	Hardness HRC at a distance, in millimetres, from quenched end of test piece															Quenching temperature
Name		1,5	3	5	7	9	11	13	15	20	25	30	35	40	45	50	°C
18NiCrMo14–6+H	max.	48	47	47	46	46	46	46	46	46	46	45	45	44	44	43	830 ± 5
	min.	40	39	39	38	38	38	38	37	37	36	34	33	32	31	30	
16NiCrMo16–5+H	max.	48	47	47	46	46	46	46	46	46	46	45	45	44	44	43	830 ± 5
	min.	40	39	39	38	38	38	38	37	37	36	34	33	32	31	30	
C56E2+H[a]	max.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	min.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
56Mn4+H[a]	max.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	min.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
70Mn4+H[a]	max.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	min.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
43CrMo4+H	max.	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45	840 ± 5
	min.	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29	

[a] Requirements for hardenability may be agreed upon.

Table 6 — Hardness in the usual conditions of delivery

Steel designation	Hardness in the delivery condition					
	+S	+A	+TH	+AC [a]	+AC+C[a]	+FP
Name	HBW max.	HBW max.	HBW	HBW max.	HBW max.	HBW
Through-hardening bearing steels						
100Cr6	[b]	–	–	207	241[c, d, i]	–
100CrMnSi4–4	[b]	–	–	217	–	–
100CrMnSi6–4	[b]	–	–	217	251[d, i]	–
100CrMnSi6–6	[b]	–	–	217	251[d, i]	–
100CrMo7	[b]	–	–	217	251[d, i]	–
100CrMo7–3	[b]	–	–	230	–	–
100CrMo7–4	[b]	–	–	230	260 [i]	–
100CrMnMoSi8–4-6	[b]	–	–	230	–	–
Case-hardening bearing steels						
20Cr3	[e]	207	156 to 207	170	[f]	–
20Cr4	[e]	207	156 to 207	170	[f]	140 to 187
20MnCr4–2	255	207	163 to 207	170	[f]	–
17MnCr5	[e]	207	156 to 207	170	[f]	140 to 187
19MnCr5	255	217	170 to 217	179	[f]	152 to 201
15CrMo4	255	207	156 to 207	170	[f]	137 to 184
20CrMo4	255	207	163 to 207	170	[f]	146 to 193
20MnCrMo4–2	255	207	156 to 207	170	[f]	146 to 193
20MnNiCrMo3–2	[e]	212	163 to 212	170	[f]	149 to 194
20NiCrMo7	255	229	174 to 229	170	[f]	154 to 207
18CrNiMo7–6	255	229	179 to 229	179	[f]	159 to 207
18NiCrMo14–6	255	–	–	241	[f]	–
16NiCrMo16–5	255	–	–	241	[f]	–
Induction-hardening bearing steels						
C56E2	255[g]	229	–	–	–	–
56Mn4	255[g]	229	–	–	–	–
70Mn4	255[g]	241	–	–	–	–
43CrMo4	255[g]	241	–	–	–	–
Stainless bearing steels						
X47Cr14	[h]	–	–	248	[f]	–
X65Cr14	[h]	–	–	255	[f]	–
X108CrMo17	[h]	–	–	255	[f]	–
X40CrMoVN16–2	[h]	–	–	255	[f]	–
X89CrMoV18–1	[h]	–	–	255	[f]	–

Table 6 — *(continued)*

Steel designation	Hardness in the delivery condition					
	+S	+A	+TH	+AC [a]	+AC+C[a]	+FP
Name	HBW max.	HBW max.	HBW	HBW max.	HBW max.	HBW
High-temperature bearing steels						
33CrMoV12–9	h	–	–	255	f	–
80MoCrV42–16	h	–	–	248	f	–
13MoCrNi42–16–14	h	269	–	–	–	–
X82WMoCrV6–5-4	h	–	–	248	f	–
X75WCrV18–4-1	h	–	–	269	f	–

a For case-hardening steels, this condition is applied if cold forming operations are intended. For through-hardening, stainless and high-temperature bearing steels, this condition is also used if the steel is processed by machining operations.

b If this condition is needed, maximum hardness values and requirements concerning the structure are to be agreed upon at the time of enquiry and order.

c The hardness of wire for needle bearings shall be up to 331 HBW. The maximum Vickers hardness value (HV) must be agreed upon at the time of enquiry and order.

d The hardness for cold-finished tubes shall be up to 321 HBW.

e Under suitable conditions, this grade is shearable in the untreated condition.

f Depending on the degree of cold working, the values may be up to about 50 HBW above those for condition +AC. Where necessary, exact requirements may be agreed upon at the time of enquiry and order.

g Depending on the chemical composition of the cast, and on the dimensions condition +A might be necessary.

h Shearability will, in general, only apply in condition +AC or in condition +A (for grade 13MoCrNi42–16–14 only).

i The hardness for bright steel products with diameter < 13 mm must be < 320 HBW.

Table 7 — Test unit, number or sample products and test pieces and sampling and test methods for the different requirements

No.	Requirements	Test unit[a]	Number of		Sampling[b] See	Test method See
			sample products	test pieces sample product		
1a	Chemical composition (cast analysis)	C	c	c	c	c
1b	Chemical composition (product analysis)	C	≥ 1/cast	≥ 1	ISO 14284	
2	Hardenability in the end-quench test[d]	C	1/cast	1	ISO 642	ISO 642[e]
3	Hardness in the condition					
3a	+S	C, T, D[f]	for test units 1 of ≤ 50 t 2 of > 50 t ≤ 100 t 3 > 100 t	1	ISO 6506-1	ISO 6506-1
3b	+A					
3c	+TH					
3d	+AC					
3e	+AC+C					
3f	+FP					
4	Structure					
4a	Austenitic grain size[d]	C	1/cast	1	ISO 643	ISO 643
4b	Spheroidization of carbides	C, T, D [f]	g	g	g	ASTM A892 or SEP 1520[g]
4c	Distribution of carbides	C, T, D [f]	g	g	g	ISO 5949
4d	Microscopic non-metallic inclusions	C [k]	g	g	Annex A.5	Annex A.5
4e	Macroscopic non-metallic inclusions	C [k]	g	g	g	h
5	Surface decarburization[i]	C, T, S, D	g	g	ISO 3887	ISO 3887

a The tests are to be carried out for each cast, as indicated by "C" – each heat-treatment condition as indicated by "T" – each surface condition as indicated by "S" – and each dimension, as indicated by "D".

b For all requirements, the general conditions for sampling according to ISO 377 apply.

c The cast analysis shall be given by the manufacturer.

d Applies only for case-hardening and induction-hardening bearing steels.

e Quenching temperatures: see Table 5.

f Products of small differences in thickness (about 1:1,5) can be considered as one test unit.

g Shall be agreed upon at the time of enquiry and order.

h Depending on the agreement at the time of enquiry and order, either the blue fracture test (see ISO 3763) or the etching test (see ISO 4969) or the step down test or the non-destructive test.

i Applies only for through-hardening, stainless and high-temperature bearing steels.

k The test unit may be agreed upon at the time of enquiry and order.

Annex A
(normative)

Supplementary or special requirements

A.1 Introduction

One or more of the following supplementary or special requirements shall 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.2 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.

A.3 Verification of grain size

Fine grain steel shall have an austenite grain size of 5 or finer. If specific testing is ordered, the grain size requirement is to be verified by determining the aluminium content or micrographically. The fine grain structure is normally achieved, when the total aluminium content is a minimum of 0,018 % of case hardening bearing steels and a minimum of 0,007 % of the induction hardening bearing steels. In such cases, the micrographic investigation is not necessary. The aluminium content shall be given in the inspection document.

Otherwise, one test piece per cast shall be inspected for the determination of the austenitic grain size. Sampling and sample preparation shall be as specified in ISO 643. The case hardening bearing steels shall be tested in accordance with the Mc-Quaid-Ehn method and the induction hardening bearing steels in accordance with the Bechet-Beaujard method as described in ISO 643. The grain structure shall be considered satisfactory if 70 % of the area is within the specified size limits.

A.4 Degree of spheroidization

If necessary, the required degree of spheroidization shall be agreed at the time of enquiry and order according to SEP 1520 or ASTM A892.

A.5 Distribution of carbides

The carbides shall be distributed as agreed upon in accordance with ISO 5949. When making such agreements, the steel grade and the size of the product shall be taken into account.

If the verification of the carbide distribution is required, the details of this shall also be agreed upon.

NOTE The size of globular carbides and the share of perlite area are not specified in ISO 5949. For these characterstics, additional requirements may be agreed upon at the time of enquiry and order.

A.6 Verification of the microscopic inclusions

Several methods for characterization and diagrams may be used, such as ISO 4967. The actual method of assessment, criteria and limits for determining the content of non-metallic inclusions are to be defined at the time of enquiry and order.

If there is no agreement at the time of enquiry and order, the content of non-metallic inclusions has to be determined at the discretion of the manufacturer according to ISO 4967, method A or JIS G0555 annex C and to the criteria listed below in Table A.1 and Table A.2.

Table A.1 — Requirements for the microscopic assessment of content of non-metallic inclusions in accordance with ISO 4967, method A[a,b]

Inclusion type	Through-hardening bearing steels	Case-hardening bearing steels	Induction-hardening bearing steels	Stainless bearing steels
A (fine)	2,5[c]	2,5[c]	2,5[c]	2,5[c]
A (thick)	1,5[c]	1,5[c]	1,5[c]	2,0[c]
B (fine)	2,0	2,0	2,0	2,5
B (thick)	1,0	1,0	1,0	2,0
C (fine)	0,5[d]	0,5	0,5	1,0[d]
C (thick)	0,5[d]	0,5	0,5	1,0[d]
D (fine)	1,0	1,0	1,0	2,0
D (thick)	1,0	1,0	1,0	1,5
DS	2,0	2,0	2,0	2,5
The method for assessment and the criteria shall be by the "worst field" method, as defined in ISO 4967 (method A) using a severity rating of 0 – 5 (JK charts). The worst field for each individual inclusion type shall be recorded and a mean value calculated. Acceptance limits are shown above.				

[a] Method A of ISO 4967 expresses the results as an average, calculated as the sum of the worst fields (in each sample) for each inclusion type divided by the number of samples.

[b] The values are applicable for a sample with a minimum reduction of 3:1.

[c] These limits are valid for sulfur contents of max. 0,015 %.

[d] Only applicable for Al-killed steels, for Si-killed steels the values shall be agreed at the time of enquiry and order.

Table A.2 — Requirements for the microscopic assessment of content of non-metallic inclusions in accordance with JIS G0555, Annex C[a]

Type of non-metallic inclusion	Index of cleanliness C_i
Type A	max. 0,15 %
Type A + C	max. 0,05 %
Type A + B + C	max. 0,18 %
The method for assessment and the criteria shall be a full set of total numbers of fields for a given index relative to the various types of inclusions. It may be used in the special methods for expressing results, i.e. i_{tot} or mean index i_{mean}. Acceptance limits are shown above.	

[a] The values are applicable for a sample with a minimum reduction of 3:1.

A.7 Non-destructive testing

The products shall be non-destructive tested under conditions and according to an acceptance standard agreed upon at the time of enquiry and order.

A.8 Surface quality

The surface quality shall comply with the requirements agreed upon at the time of enquiry and order. Also the details for sampling and for preparation of the test pieces for testing the surface quality shall be agreed upon at the time of enquiry and order.

A.9 Special dimensional inspection

An agreed number of products shall be inspected for their shape and dimensions.

A.10 Special agreements for marking

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

Annex B
(informative)

Designations of the steels given in Tables 3, 5 and 6 and of comparable grades covered in various designation systems

Table B.1 — Designations of the steels given in Tables 3, 5 and 6 and of comparable grades covered in various designation systems

Steel designations according to[a]										
ISO steel grade (ISO 683-17)	ASTM/UNS[b]		ISO 683-17[c]			JIS[d]		GB/ISC[e]		
	Design	i/n/w[f]	Design		i/n/w[f]	Design	i/n/w[f]	Design.	ISC	i/n/w[f]
Through-hardening bearing steels										
100Cr6	–	–	100Cr6	1.3505	i	SUJ2	n	GCr15	B00150	n
100CrMnSi4–4	–	–	100CrMnSi4–4	1.3518	i	SUJ3	n	–	–	–
100CrMnSi6–4	–	–	100CrMnSi6–4	1.3520	i	–	–	GCr15SiMn	B01150	n
100CrMnSi6–6	–	–	100CrMnSi6–6	1.3519	i	–	–	–	–	–
100CrMo7	–	–	100CrMo7	1.3537	i	–	–	GCr18Mo	B02180	n
100CrMo7–3	–	–	100CrMo7–3	1.3536	i	–	–	–	–	–
100CrMo7–4	–	–	100CrMo7–4	1.3538	i	–	–	–	–	–
100CrMn-MoSi8–4-6	–	–	100CrMn-MoSi8–4-6	1.3539	i	–	–	–	–	–
Case-hardening bearing steels										
20Cr3	–	–	20Cr3	1.3559	i	–	–	–	–	–
20Cr4	–	–	20Cr4	1.7027	i	SCr420	n	–	–	–
20MnCr4–2	–	–	20MnCr4–2	1.3515	i	–	–	–	–	–
17MnCr5	–	–	17MnCr5	1.3521	i	–	–	–	–	–
19MnCr5	–	–	19MnCr5	1.3523	i	–	–	–	–	–
15CrMo4	–	–	15CrMo4	1.3566	i	SCM415	N	–	–	–
20CrMo4	–	–	20CrMo4	1.3567	i	SCM420	N	–	–	–
20MnCrMo4–2	–	–	20MnCrMo4–2	1.3570	i	–	–	G20CrMo	B10200	n
20MnNiCrMo3–2	–	–	20MnNi-CrMo3–2	1.6522	i	SNCM220	N	G20CrNiMo	B12200	n
20NiCrMo7	–	–	20NiCrMo7	1.3576	i	SNCM420	n	G20CrNi2Mo	B12210	n
18CrNiMo7–6	–	–	18CrNiMo7–6	1.6587	i	–	–	–	–	–
18NiCrMo14–6	–	–	18NiCrMo14–6	1.3533	i	–	–	G20Cr2Ni4	B11200	n
16NiCrMo16–5	–	–	16NiCrMo16–5	1.3532	i	–	–	–	–	–

Table B.1 — *(continued)*

Steel designations according to[a]										
ISO steel grade (ISO 683-17)	**ASTM/UNS[b]**		ISO 683-17[c]			**JIS[d]**		**GB/ ISC[e]**		
	Design	**i/n/w[f]**	**Design**		**i/n/w[f]**	**Design**	**i/n/w[f]**	**Design**	**ISC**	**i/n/w[f]**
Induction-hardening bearing steels										
C56E2	–	–	C56E2	1.1219	i	S55C	N	G55	B30550	n
56Mn4	–	–	56Mn4	1.1233	i	–	–	G55Mn	B31550	n
70Mn4	–	–	70Mn4	1.1244	i	–	–	G70Mn	B31700	n
43CrMo4	–	–	43CrMo4	1.3563	i	SCM440	N	G42CrMo	B33422	n
Stainless bearing steels										
X47Cr14	–	–	X47Cr14	1.3541	i	–	–	–		–
X65Cr14	–	–	X65Cr14	1.3542	i	–	–	–		–
X108CrMo17	–	–	X108CrMo17	1.3543	i	SUS440C	N	G9Cr18Mo	B21819	n
X40CrMoVN16–2	–	–	X40CrMoVN16–2	1.4123	i	–	–	–		–
X89CrMoV18–1	–	–	X89CrMoV18–1	1.3549	i	–	–	–		–
High-temperature bearing steels										
33CrMoV12–9	–	–	33CrMoV12–9	1.8522	i	–	–	–		-
80MoCrV42–16	–	–	80MoCrV42–16	1.3551	i	–	–	G8Cr-4Mo4V	B20440	n
13MoCrNi42–16–14	–	–	13MoCrNi42–16–14	1.3555	i	–	–	G13Cr-4Mo4Ni4V	B20443	n
X82WMoCrV6–5-4	–	–	X82WMoCrV6–5-4	1.3553	i	SKH51	n	–		–
X75WCrV18–4-1	–	–	X75WCrV18–4-1	1.3558	i	SKH2	n	–		–

[a] See sources in the Bibliography.

[b] US steel listed in ASTM and in UNS – if the steel number is given in brackes then the steel has only a UNS-number.

[c] European steel listed in ISO 683-17 and in the “Stahl-Eisen-Liste” (the Register of European Steels). If the steel number is given in brackets then the steel is only listed in the “Stahl-Eisen-Liste”.

[d] Japanese Industrial Standard.

[e] Chinese National Standard.

[f] i = identical steel to ISO steel grade, *n* = steel grade with closer match of composition, but not identical, w = wider match.

Annex C
(informative)

Dimensional standards applicable to products complying with this part of ISO 683

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

[2] ISO 1035-2, *Hot-rolled steel bars — Part 2: Dimensions of square bars*

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

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

[5] ISO 16124, *Steel wire rod — Dimensions and tolerances*

[6] ISO 22034-2, *Steel wire and wire products — Part 2: Tolerances on wire dimensions*

Bibliography

[1] EN 10027-2, *Designation Systems for steels — Part 2: Numerical system*

[2] EN 10204, *Metallic products — Types of inspection documents*

[3] JIS G0415, *Steel and steel products — Inspection documents*

[4] JIS G0555, *Microscopic testing method for the non-metallic inclusions in steel*

[5] ASTM A892, *Standard Guide for Defining and Rating the Microstructure of High Carbon Bearing Steels*

[6] SEP 1520, *Microscopic examination of carbide structure in steels by means of diagram series*

[7] EN 10278, *Dimensions and tolerances of bright steel products*

[8] EN 10247, *Micrographic examination of the non-metallic inclusion content of steels using standard pictures*

[9] GB/T 3086, High carbon chromium stainless bearing steels

[10] GB/T 3203, Specification for carburizing steels of bearings

[11] GB/T 18254, High-carbon chromium bearing steel

[12] GB/T 28417, Carbon bearing steel

ICS 77.140.10;77.140.20

Price based on 25 pages