

# INTERNATIONAL STANDARD

**ISO**  
**683-17**

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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*



Reference number  
ISO 683-17:1999(E)

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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 3.

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 683-17 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 4, *Heat treatable and alloy steels*. This second edition cancels and replaces the first edition (ISO 683-17:1976), which has been technically revised.

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

- *Part 1: Direct-hardening unalloyed and low-alloyed wrought steels 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*

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



# 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 applies to the products and heat-treatment conditions given in Table 1 and the surface conditions given in Table 2.

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

- a) through-hardening bearing steels (steels with about 1 % C and 1 % to 2 % Cr);
- b) case-hardening bearing steels;
- c) induction-hardening bearing steels (unalloyed and alloyed);
- d) stainless bearing steels;
- e) high temperature bearing steels.

1.3 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).

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

### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 683. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 683 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 3763:1976, *Wrought steels — Macroscopic methods for assessing the content of non-metallic inclusions.*

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 4967:1998, *Steel — Determination of content of nonmetallic inclusions — Micrographic method using standard diagrams.*

ISO 4969:1980, *Steel — Macroscopic examination by etching with strong mineral acids.*

ISO 5949:1983, *Tool steels and bearing steels — Micrographic method for assessing the distribution of carbides using reference photomicrographs.*

ISO 6506:1981<sup>1)</sup>, *Metallic materials — Hardness test — Brinell test.*

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

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

ISO/TR 9769:1991, *Steel and iron — Review of available methods of analysis.*

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.*

ENV 10247:1996, *Metallographic test methods — Examination of steels using standard diagrams to assess the content of non-metallic inclusions.*

### 3 Terms and definitions

For the purposes of this part of ISO 683, the terms and definitions for the product forms given in ISO 6929 apply. The terms "unalloyed steel" and "alloyed steel" are as defined in ISO 4948-1.

### 4 Ordering and designation

The designation of the product on an order shall cover the following.

- a) The designation of the product form (e. g. bar) followed by
  - 1) either the designation of the dimensional standard and the dimensions and tolerances selected from it (see 5.6) or
  - 2) the designation of 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
  - 1) the surface condition (see Table 2), and
  - 2) the surface quality (see 5.5).
- c) A description of the steel comprising
  - 1) a reference to this part of ISO 683;
  - 2) the designation of the steel type (see Table 3);
  - 3) the symbol for the heat-treatment condition on delivery (see Table 1);
  - 4) the standard designation for the required type of inspection document (see ISO 10474);
  - 5) the symbol and, where necessary, the details of this supplementary requirement (see annex A), if any supplementary requirement shall be complied with.

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<sup>1)</sup> This International Standard has been replaced by ISO 6506-1, ISO 6506-2 and ISO 6506-3.

## EXAMPLE

The following are to be ordered.

Hot-rolled round bars

- a) in accordance with ISO 1035-1;
- b) with a nominal diameter of 50,0 mm;
- c) with a nominal length of 8 000 mm;
- d) with a tolerance on diameter of  $\pm 0,40$  mm (class S of ISO 1035-4);
- e) with a tolerance on length of  ${}^{+100}_0$  mm (class L2 of ISO 1035-4);
- f) all other tolerances as given in ISO 1035-4, for normal cases.

Surface

- a) as hot worked

Steel

- a) in accordance with this part of ISO 683, type 100Cr6 (see Table 3);
- b) heat-treatment condition: annealed to achieve spheroidized carbides (symbol +AC, see Table 1);
- c) with an inspection certificate 3.1.B (see ISO 10474).

Designation

Rounds ISO 1035-1-50,0 S  $\times$  8 000 L2

Steel ISO 683-17-100Cr6+AC-3.1.B

## 5 Requirements

### 5.1 Manufacturing process

#### 5.1.1 General

The manufacturing process of the steel and of the products is, with the restrictions given by the requirements in 5.1.2 and 5.1.3, left to the discretion of the manufacturer.

When he so requests, the purchaser shall be informed on the steel-making process used.

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

#### 5.1.2 Heat-treatment and surface condition at delivery

The heat-treatment and surface condition at delivery shall be as agreed when ordering.

Table 1 in combination with Table 6 covers the various product forms' and steel groups' usual heat-treatment conditions, and Table 2 the usual surface conditions.

#### 5.1.3 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 on 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).

**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 are applied – the requirements for chemical composition and hardness cited in Table 1, column 10, 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, ordered to hardenability requirements, the values of hardenability given in Table 5 apply in addition to the requirements cited in Table 1, column 10 (see footnote b to Table 3).

## 5.3 Microstructure

### 5.3.1 Austenitic grain size of case-hardening and induction-hardening bearing steels

Case-hardening steels and induction-hardening steels shall be fine grained. This requirement shall be regarded as complied with if

- a) in the case of case-hardening steels after holding the steel for 4 h at  $(925 \pm 10)$  °C, at least 70 % of the microstructure revealed according to one of the procedures given in ISO 643 consists of grains of size 5 or finer;
- b) in the case of induction hardening steels after holding for 1,5 h at  $(850 \pm 10)$  °C the microstructure revealed according to one of the procedures given in ISO 643 consists of grains of size 5 or finer.

For verification of the grain size see annex A.1.

### 5.3.2 Spheroidization and distribution of carbides

**5.3.2.1** 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. If necessary, the required degree of spheroidization shall be agreed at the time of enquiry and order.

**5.3.2.2** For distribution of carbides, see annex A.2.

### 5.3.3 Structure of case-hardening steels in the condition +FP

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

## 5.4 Non-metallic inclusions

All bearing steels shall have a high degree of cleanness, i.e. a low content of non-metallic inclusions.

For microscopic non-metallic inclusions, see annex A.3 and annex B.

For macroscopic non-metallic inclusions, see annex A.4.

## 5.5 Surface quality

**5.5.1** All products shall have a workmanlike finish.

**5.5.2** Ground or turned or machined products shall be free from surface imperfections and surface decarburization.



**5.5.3** Hot-rolled, forged, cold-reduced, peeled or rough-machined products shall be ordered with sufficient material machining allowances to be removed from all surfaces by machining or grinding to allow for:

- a) surface decarburization and
- b) surface imperfections.

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.

## **5.6 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 or, otherwise, on suitable national standards.

**NOTE** For round bars, the following International Standards cover dimensions and/or tolerances for products included in this part of ISO 683:

ISO 1035-1 and ISO 1035-4.

## **6 Inspection, testing and conformance of products**

### **6.1 Inspection and testing procedures and types of inspection documents**

**6.1.1** For each delivery, the issue of any 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 made at the time of enquiry and order, a test report is to be provided, this shall cover:

- a) the statement that the material complies with the requirements of the order;
- b) the results of the cast analysis for all elements specified for the type of steel supplied.

**6.1.3** If, in accordance with the agreements in the order, an inspection certificate 3.1.A, 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) the results of the cast analysis provided by the manufacturer for all elements specified for the steel type concerned;
- b) the results of all inspections and tests ordered by supplementary requirements (see annex A);
- c) the symbol letters or numbers connecting the inspection document with the relevant test unit.

### **6.2 Specific inspection and testing**

#### **6.2.1 General**

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.

#### **6.2.2 Chemical composition**

The cast analysis is given by the manufacturer. For product analysis see annex A.5.

### 6.2.3 Verification of the hardenability and hardness

The hardness requirements given for the relevant heat treatment condition in Table 1, column 10, sub-column ii, 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.

### 6.2.4 Inspection of the surface quality

**6.2.4.1** Unless otherwise agreed when ordering (see annex A.7), the number of products to be inspected for surface quality is left to the discretion of the inspector.

**6.2.4.2** Unless otherwise agreed (see annex A.7), the surface quality shall be inspected visually.

### 6.2.5 Dimensional inspection

Unless otherwise agreed when ordering (see annex A.8) the number of products to be inspected for their shape and dimensions shall be left to the discretion of the inspector.

### 6.2.6 Retests

For retests, ISO 404 shall apply.

## 7 Marking

The manufacturer shall mark the products or the bundles or boxes containing the products in a suitable way, so that identification of the cast, the steel type and the origin of the delivery is possible (see annex A.6).

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

1	2	3	4						9	10			11
			Symbol	X = Applicable for						Applicable requirements if the steel is ordered with the designation given in Table 5			
Heat-treatment condition at delivery	Symbol	billets	bars	rod	wire	tubes	rings and discs	i	ii	i	ii	iii	
1	Untreated	X	X	X	-	-	-	-	-	-	-	-	
2	Treated for cold shearability	X	-	-	-	-	-	-	-	-	-	-	
3	Annealed (soft annealed)	-	X	X	-	-	-	-	-	-	-	-	
4	Stress relieved	-	-	-	X	X	X	-	-	-	-	-	
5	Treated to hardness range	-	X	X	-	-	X	-	-	-	-	-	
6	Annealed to achieve spheroidized carbides	-	X	X	X	X	X	X	-	-	-	-	
7	Annealed to achieve spheroidized carbides and cold-worked	-	X	-	X	-	X	-	-	-	-	-	
8	Isothermally treated to ferrite-perlite structure and hardness range	-	X	X	-	-	X	-	-	-	-	-	
9	Others	-	-	-	-	-	-	-	-	-	-	-	
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	10
	Surface condition at delivery		Symbol	X = In general applicable for					
				billets	bars	rod <sup>a</sup>	wire <sup>a</sup>	tubes	rings and discs
1	Unless otherwise agreed	As hot worked	None or HW	X	X	X	-	X	X
2		Peeled	P	-	X	-	-	-	-
3		Turned	T	-	X	X	X	X	-
4		Ground	GR	-	X	-	-	-	-
5		Machined	MA	-	-	-	-	-	X
6	Particular conditions supplied by agreement	Cold drawn	CD	-	X	-	X	X	-
7		Cold pilgered (rocked)	CP	-	-	-	-	X	-
8		Cold rolled	CR	-	-	-	-	-	X
9		Others	As agreed						
10									

<sup>a</sup> Cold drawn rod is by definition wire (see ISO 6929).

Table 3 — Types of steel and specified chemical composition (applicable to cast analysis)

No.	Type of steel Name	Chemical composition <sup>a, b</sup> [% (m/m)]											Others
		C	Si	Mn	P max.	S max.	Cr	Mo	Ni	V	W		
<b>Through-hardening bearing steels</b>													
B1	100Cr6	0,93 to 1,05 <sup>c</sup>	0,15 to 0,35 <sup>d</sup>	0,25 to 0,45	0,025	0,015 <sup>e</sup>	1,35 to 1,60	max. 0,10					Al: max. 0,050
B2	100CrMnSi4-4	0,93 to 1,05 <sup>c</sup>	0,45 to 0,75	0,90 to 1,20	0,025	0,015 <sup>e</sup>	0,90 to 1,20	max. 0,10					Ca: <sup>f</sup>
B3	100CrMnSi6-4	0,93 to 1,05 <sup>c</sup>	0,45 to 0,75	1,00 to 1,20	0,025	0,015 <sup>e</sup>	1,40 to 1,65	max. 0,10					Cu: max. 0,30
B4	100CrMnSi6-6	0,93 to 1,05 <sup>c</sup>	0,45 to 0,75	1,40 to 1,70	0,025	0,015 <sup>e</sup>	1,40 to 1,65	max. 0,10					
B5	100CrMo7	0,93 to 1,05 <sup>c</sup>	0,15 to 0,35	0,25 to 0,45	0,025	0,015 <sup>e</sup>	1,65 to 1,95	0,15 to 0,30					
B6	100CrMo7-3	0,93 to 1,05 <sup>c</sup>	0,15 to 0,35	0,60 to 0,80	0,025	0,015 <sup>e</sup>	1,65 to 1,95	0,20 to 0,35					
B7	100CrMo7-4	0,93 to 1,05 <sup>c</sup>	0,15 to 0,35	0,60 to 0,80	0,025	0,015 <sup>e</sup>	1,65 to 1,95	0,40 to 0,50					O: max. 0,0015 <sup>g</sup>
B8	100CrMnMoSi8-4-6	0,93 to 1,05 <sup>c</sup>	0,40 to 0,60	0,80 to 1,10	0,025	0,015 <sup>e</sup>	1,80 to 2,05	0,50 to 0,60					Ti: <sup>h</sup>
<b>Case-hardening bearing steels</b>													
B20	20Cr3	0,17 to 0,23	max. 0,40	0,60 to 1,00	0,025	0,015 <sup>e</sup>	0,60 to 1,00						
B21	20Cr4	0,17 to 0,23	max. 0,40	0,60 to 0,90	0,025	0,015 <sup>e</sup>	0,90 to 1,20						
B22	20MnCr4-2	0,17 to 0,23	max. 0,40	0,65 to 1,10	0,025	0,015 <sup>e</sup>	0,40 to 0,75						
B23	17MnCr5	0,14 to 0,19	max. 0,40	1,00 to 1,30	0,025	0,015 <sup>e</sup>	0,80 to 1,10						Al: max. 0,050
B24	19MnCr5	0,17 to 0,22	max. 0,40	1,10 to 1,40	0,025	0,015 <sup>e</sup>	1,00 to 1,30						Ca: <sup>f</sup>
B25	15CrMo4	0,12 to 0,18	max. 0,40	0,60 to 0,90	0,025	0,015 <sup>e</sup>	0,90 to 1,20	0,15 to 0,25					Cu: max. 0,30
B26	20CrMo4	0,17 to 0,23	max. 0,40	0,60 to 0,90	0,025	0,015 <sup>e</sup>	0,90 to 1,20	0,15 to 0,25					
B27	20MnCrMo4-2	0,17 to 0,23	max. 0,40	0,65 to 1,10	0,025	0,015 <sup>e</sup>	0,40 to 0,75	0,10 to 0,20					
B28	20NiCrMo2	0,17 to 0,23	max. 0,40	0,60 to 0,95	0,025	0,015 <sup>e</sup>	0,35 to 0,65	0,15 to 0,25	0,40 to 0,70				
B29	20NiCrMo7	0,17 to 0,23	max. 0,40	0,40 to 0,70	0,025	0,015 <sup>e</sup>	0,35 to 0,65	0,20 to 0,30	1,60 to 2,00				
B30	18CrNiMo7-6	0,15 to 0,21	max. 0,40	0,50 to 0,90	0,025	0,015 <sup>e</sup>	1,50 to 1,80	0,25 to 0,35	1,40 to 1,70				
B31	18NiCrMo14-6	0,15 to 0,20	max. 0,40	0,40 to 0,70	0,025	0,015 <sup>e</sup>	1,30 to 1,60	0,15 to 0,25	3,25 to 3,75				
B32	16NiCrMo16-5	0,14 to 0,18	max. 0,40	0,25 to 0,55	0,025	0,015 <sup>e</sup>	1,00 to 1,40	0,20 to 0,30	3,80 to 4,30				

Table 3 (concluded)

No.	Type of steel Name	Chemical composition <sup>a, b</sup> [% (m/m)]											Others
		C	Si	Mn	P max.	S max.	Cr	Mo	Ni	V	W		
<b>Induction-hardening bearing steels</b>													
B40	C56E2	0,52 to 0,60	max. 0,40	0,60 to 0,90	0,025	0,015 <sup>e</sup>							Al: max. 0,050
B41	56Mn4	0,52 to 0,60	max. 0,40	0,90 to 1,20	0,025	0,015 <sup>e</sup>							Ca: f
B42	70Mn4	0,65 to 0,75	max. 0,40	0,80 to 1,10	0,025	0,015 <sup>e</sup>							Cu: max. 0,30
B43	43CrMo4	0,40 to 0,46	max. 0,40	0,60 to 0,90	0,025	0,015 <sup>e</sup>	0,90 to 1,20	0,15 to 0,30					O: max. 0,0020 g Ti: h
<b>Stainless bearing steels</b>													
B50	X47Cr14	0,43 to 0,50	max. 1,00	max. 1,00	0,040	0,015 <sup>e</sup>	12,50 to 14,50						
B51	X65Cr14	0,60 to 0,70	max. 1,00	max. 1,00	0,040	0,015 <sup>e</sup>	12,50 to 14,50	max. 0,75					
B52	X108CrMo17	0,95 to 1,20	max. 1,00	max. 1,00	0,040	0,015 <sup>e</sup>	16,00 to 18,00	0,40 to 0,80					
B53	X89CrMoV18-1	0,85 to 0,95	max. 1,00	max. 1,00	0,040	0,015 <sup>e</sup>	17,00 to 19,00	0,90 to 1,30	0,07 to 0,12				
<b>High-temperature bearing steels</b>													
B60	80MoCrV42-16	0,77 to 0,85	max. 0,40	0,15 to 0,35	0,025 <sup>i</sup>	0,015 <sup>i</sup>	3,90 to 4,30	4,00 to 4,50		0,90 to 1,10	max. 0,25		Cu: max. 0,30
B61	13MoCrNi42-16-14	0,10 to 0,15	0,10 to 0,25	0,15 to 0,35	0,015	0,010	3,90 to 4,30	4,00 to 4,50	3,20 to 3,60	1,00 to 1,30	max. 0,15		Cu: max. 0,10 j
B62	X82WMoCrV6-5-4	0,78 to 0,86	max. 0,40	max. 0,40	0,025	0,015	3,90 to 4,30	4,70 to 5,20		1,70 to 2,00	6,00 to 6,70		Cu: max. 0,30
B63	X75WCrV18-4-1	0,70 to 0,80	max. 0,40	max. 0,40	0,025	0,015	3,90 to 4,30	max. 0,60		1,00 to 1,25	17,50 to 19,00		Cu: max. 0,30

<sup>a</sup> Elements not quoted 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 in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

<sup>b</sup> 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 in the case of carbon  $\pm 0,01$  % (m/m) and in all other cases the values according to Table 4.

<sup>c</sup> 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.

<sup>d</sup> By agreement max. 0,15 % (m/m) Si for cold forming.

<sup>e</sup> Where machinability is of primary importance, max. 0,030 % (m/m) sulfur may be agreed at the time of enquiry and order.

<sup>f</sup> Intentional additions of calcium or calcium alloys for deoxidation or inclusion shape control are not permitted unless specifically approved by the purchaser.

<sup>g</sup> Oxygen content applies to product analysis.

<sup>h</sup> A maximum titanium content may be agreed upon at the time of enquiry and order.

<sup>i</sup> Max. 0,015 % (m/m) phosphorus and max. 0,08 % (m/m) sulfur may be agreed upon at the time of enquiry and order.

<sup>j</sup> Max. 0,20 % (m/m) Cu 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 $x$ % (m/m)	Permissible deviation <sup>a</sup> , % (m/m) for				
		through-hardening bearing steels	case-hardening bearing steels	induction-hardening bearing steels	stainless bearing steels	high-temperature bearing steels
<b>C</b>	$x \leq 0,60$	—	$\pm 0,02$	$\pm 0,02$	$\pm 0,02$	$\pm 0,02$
	$0,60 < x \leq 1,20$	$\pm 0,03$	—	$\pm 0,03$	$\pm 0,03$	$\pm 0,03$
<b>Si</b>	$x \leq 0,40$	$\pm 0,03$	$\pm 0,03$	+ 0,03	—	$\pm 0,03$
	$0,40 < x \leq 1,00$	$\pm 0,05$	—	—	+ 0,05	—
<b>Mn</b>	$x \leq 1,00$	$\pm 0,04$	$\pm 0,04$	$\pm 0,04$	+ 0,03	$\pm 0,04$
	$1,00 < x \leq 1,40$	$\pm 0,06$	$\pm 0,06$	$\pm 0,06$	—	—
<b>P</b>	$x \leq 0,040$	+ 0,005	+ 0,005	+ 0,005	+ 0,005	+ 0,005
<b>S</b>	$x \leq 0,025$	+ 0,005	+ 0,005	+ 0,005	+ 0,005	+ 0,005
<b>Cr</b>	$x \leq 2,00$	$\pm 0,05$	$\pm 0,05$	$\pm 0,05$	—	—
	$2,00 < x \leq 10,00$	$\pm 0,10$	—	—	—	$\pm 0,10$
	$10,00 < x \leq 15,00$	—	—	—	$\pm 0,15$	—
	$15,00 < x \leq 19,00$	—	—	—	$\pm 0,20$	—
<b>Mo</b>	$x \leq 0,30$	$\pm 0,03$	$\pm 0,03$	$\pm 0,03$	—	—
	$0,30 < x \leq 0,60$	$\pm 0,05$	$\pm 0,05$	—	$\pm 0,05$	+ 0,03
	$0,60 < x \leq 1,75$	—	—	—	—	—
	$1,75 < x \leq 5,20$	—	—	—	—	$\pm 0,10$
<b>Ni</b>	$x \leq 1,00$	—	$\pm 0,03$	—	—	—
	$1,00 < x \leq 2,00$	—	$\pm 0,05$	—	—	—
	$2,00 < x \leq 4,30$	—	$\pm 0,07$	—	—	$\pm 0,07$
<b>V</b>	$x \leq 0,50$	—	—	—	$\pm 0,03$	—
	$0,50 < x \leq 1,50$	—	—	—	—	$\pm 0,05$
	$1,50 < x \leq 2,00$	—	—	—	—	$\pm 0,10$
<b>W</b>	$x \leq 0,25$	—	—	—	—	$\pm 0,03$
	$5,00 < x \leq 10,00$	—	—	—	—	$\pm 0,10$
	$10,00 < x \leq 19,00$	—	—	—	—	$\pm 0,20$
<b>Al</b>	$x \leq 0,050$	+ 0,010	+ 0,010	+ 0,010	—	—
<b>Cu</b>	$x \leq 0,30$	+ 0,03	+ 0,03	+ 0,03	—	+ 0,03

<sup>a</sup>  $\pm$  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.

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

No.	Type of steel Name	Limits of range	Hardness HRC at a distance, in millimeters, from quenched end of test piece of																	Quenching temperature °C
			1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50			
B20	20Cr3+H	max. min.	48 40	46 34	41 27	34 22	31 20	29 —	27 —	25 —	22 —	—	—	—	—	—	—	—	900 ± 5	
B21	20Cr4+H	max. min.	49 41	48 38	46 31	42 26	38 23	36 21	34 —	32 —	29 —	27 —	26 —	24 —	23 —	—	—	—	900 ± 5	
B22	20MnCr4-2+H	max. min.	49 41	48 38	46 31	42 26	39 23	37 21	34 —	33 —	32 —	30 —	28 —	26 —	24 —	—	—	—	900 ± 5	
B23	17MnCr5+H	max. min.	47 39	46 36	44 31	41 28	39 24	37 21	35 —	33 —	31 —	30 —	29 —	28 —	27 —	—	—	—	900 ± 5	
B24	19MnCr5+H	max. min.	49 41	49 39	48 36	46 33	43 30	42 28	41 26	39 25	37 23	35 21	34 —	33 —	32 —	—	—	—	900 ± 5	
B25	15CrMo4+H	max. min.	46 39	45 36	41 29	38 24	34 21	31 20	29 —	28 —	26 —	25 —	24 —	23 —	23 —	—	—	—	900 ± 5	
B26	20CrMo4+H	max. min.	48 40	48 39	47 35	44 31	41 28	39 25	37 24	35 23	33 20	31 20	30 —	30 —	29 —	—	—	—	900 ± 5	
B27	20MnCrMo4-2+H	max. min.	48 41	46 37	40 27	34 22	29 —	27 —	25 —	24 —	21 —	—	—	—	—	—	—	—	900 ± 5	
B28	20NiCrMo2+H	max. min.	49 41	48 37	45 31	42 25	42 22	36 20	31 —	30 —	27 —	25 —	24 —	24 —	23 —	—	—	—	900 ± 5	
B29	20NiCrMo7+H	max. min.	48 40	47 38	45 34	42 30	39 27	36 25	34 23	32 22	29 20	26 —	25 —	24 —	24 —	—	—	—	900 ± 5	
B30	18CrNiMo7-6+H	max. min.	48 40	48 40	48 39	48 38	47 37	47 36	46 35	46 34	44 32	43 31	42 30	41 29	41 29	—	—	—	860 ± 5	
B31	18NiCrMo14-6+H	max. min.	48 40	47 39	47 39	46 38	46 38	46 38	46 38	46 37	46 37	46 36	45 34	45 33	44 32	44 31	43 30	—	830 ± 5	
B32	16NiCrMo16-5+H	max. min.	48 40	47 39	47 39	46 38	46 38	46 38	46 38	46 37	46 37	46 36	45 34	45 33	44 32	44 31	43 30	—	830 ± 5	
B40	C56E2+H <sup>a</sup>	max. min.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
B41	56Mn4+H <sup>a</sup>	max. min.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
B42	70Mn4+H <sup>a</sup>	max. min.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
B43	43CrMo4+H	max. min.	61 53	61 53	61 52	60 51	60 49	59 43	59 40	58 37	56 34	53 32	51 31	48 30	47 30	46 29	45 29	—	840 ± 5	

<sup>a</sup> Requirements for hardenability may be agreed upon.



Table 6 — Hardness in the usual conditions of delivery

Number	Name	Hardness in the delivery condition					+FP HB
		+S HB max.	+A HB max.	+HR HB	+AC <sup>a</sup> HB max.	+AC <sup>a</sup> +C HB max.	
<b>Through-hardening bearing steels</b>							
B1	100Cr6	b	—	—	207	241 <sup>c, d</sup>	—
B2	100CrMnSi4-4	b	—	—	217	—	—
B3	100CrMnSi6-4	b	—	—	217	251 <sup>d</sup>	—
B4	100CrMnSi6-6	b	—	—	217	251 <sup>d</sup>	—
B5	100CrMo7	b	—	—	217	251 <sup>d</sup>	—
B6	100CrMo7-3	b	—	—	230	—	—
B7	100CrMo7-4	b	—	—	230	260	—
B8	100CrMnMoSi8-4-6	b	—	—	230	—	—
<b>Case-hardening bearing steels</b>							
B20	20Cr3	e	207	156 to 207	170	f	—
B21	20Cr4	e	207	156 to 207	170	f	140 to 187
B22	20MnCr4-2	255	207	163 to 207	170	f	—
B23	17MnCr5	e	207	156 to 207	170	f	140 to 187
B24	19MnCr5	255	217	170 to 217	179	f	152 to 201
B25	15CrMo4	255	207	156 to 207	170	f	137 to 184
B26	20CrMo4	255	207	163 to 207	170	f	146 to 193
B27	20MnCrMo4-2	255	207	156 to 207	170	f	146 to 193
B28	20NiCrMo2	e	212	163 to 212	170	f	149 to 194
B29	20NiCrMo7	255	229	174 to 229	170	f	154 to 207
B30	18CrNiMo7-6	255	229	179 to 229	179	f	159 to 207
B31	18NiCrMo14-6	255	—	—	241	f	—
B32	16NiCrMo16-5	255	—	—	241	f	—
<b>Induction-hardening bearing steels</b>							
B40	C56E2	255 <sup>g</sup>	229	—	—	—	—
B41	56Mn4	255 <sup>g</sup>	229	—	—	—	—
B42	70Mn4	255 <sup>g</sup>	241	—	—	—	—
B43	43CrMo4	255 <sup>g</sup>	241	—	—	—	—
<b>Stainless bearing steels</b>							
B50	X47Cr14	h	—	—	248	f	—
B51	X65Cr14	h	—	—	255	f	—
B52	X108CrMo17	h	—	—	255	f	—
B53	X89CrMoV18-1	h	—	—	255	f	—
<b>High-temperature bearing steels</b>							
B60	80MoCrV42-16	h	—	—	248	f	—
B61	13MoCrNi42-16-14	h	269	—	—	—	—
B62	X82WMoCrV6-5-4	h	—	—	248	f	—
B63	X75WCrV18-4-1	h	—	—	269	f	—
<p><sup>a</sup> 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.</p> <p><sup>b</sup> 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.</p> <p><sup>c</sup> The hardness of wire for needle bearings may measure up to 331 HB. The maximum Vickers hardness value (HV) must be agreed upon at the time of enquiry and order.</p> <p><sup>d</sup> The hardness for cold finished tubes may measure up to 321 HB.</p> <p><sup>e</sup> Under suitable conditions, this grade is shearable in the untreated condition.</p> <p><sup>f</sup> Depending on the degree of cold working, the values may be up to about 50 HB above those for condition +AC. Where necessary, exact requirements may be agreed upon at the time of enquiry and order.</p> <p><sup>g</sup> Depending on the chemical composition of the cast, and on the dimensions, condition +A might be necessary.</p> <p><sup>h</sup> Shearability will in general only apply in condition +AC or in condition +A (for grade 13MoCrNi42-16-14 only).</p>							

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

1	2	3	4	5	6	7
No.	Requirements	Test unit <sup>a</sup>	Number of		Sampling <sup>b</sup> see	Test method see
			sample products	test pieces per sample product		
1a	Chemical composition (cast analysis)	C	c	c	c	c
1b	Chemical composition (product analysis)	C	≥ 1/cast	≥ 1	ISO 14284	d
2	Hardenability in the end-quench test <sup>e</sup>	C	1/cast	1	ISO 642	ISO 642 <sup>f</sup>
3	Hardness in the condition					
3a	+S	C, T, D <sup>g</sup>	1, 2 resp. 3 for test units of ≤ 50 tonnes, > 50 tonnes, ≤ 100 tonnes, resp. > 100 tonnes	1	ISO 6506	ISO 6506
3b	+A	C, T, D <sup>g</sup>				
3c	+HR	C, T, D <sup>g</sup>				
3d	+AC	C, T, D <sup>g</sup>				
3e	+AC+C	C, T, D <sup>g</sup>				
3f	+FP	C, T, D <sup>g</sup>				
4	Structure					
4a	austenitic grain size <sup>e</sup>	C	1/cast	1	ISO 643	ISO 643
4b	spheroidization of carbides	C, T, D <sup>g</sup>	h	h	h	h
4c	distribution of carbides	C, T, D <sup>g</sup>	h	h	h	ISO 5949
4d	microscopic non- metallic inclusions	C, D	h	h	i	i
4e	macroscopic non- metallic inclusions	C, D	h	h	h	j
5	Surface decarburization <sup>k</sup>	C, T, S, D	h	h	ISO 3887	ISO 3887

NOTE Table 7 only applies if specific testing is ordered.

- <sup>a</sup> 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".
- <sup>b</sup> For all requirements the general conditions for sampling according to ISO 377 apply.
- <sup>c</sup> The cast analysis shall be given by the manufacturer.
- <sup>d</sup> In cases of dispute, the methods for the chemical analyses shall be those established by the relevant International Standards (see ISO/TR 9769). If no International Standards are available, the methods may be agreed upon and specified at the time of enquiry and order.
- <sup>e</sup> Applies only for case-hardening and induction-hardening bearing steels.
- <sup>f</sup> Quenching temperatures: see Table 5.
- <sup>g</sup> Products of small differences in thickness (about 1:1,5) can be considered as one test unit.
- <sup>h</sup> Shall be agreed upon at the time of enquiry and order.
- <sup>i</sup> Depending on the agreements at the time of enquiry and order, either according to ISO 4967 or ENV 10247.
- <sup>j</sup> 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 ultrasonic test.
- <sup>k</sup> Applies only for through-hardening, stainless and high-temperature bearing steels.

## **Annex A**

### **(normative)**

## **Supplementary or special requirements**

NOTE 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.1 Verification of grain size**

In cases where verification of the fine grain structure is specified, the method for the determination of grain size according to ISO 643 is also to be agreed upon at the time of enquiry and order.

### **A.2 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 characteristics, additional requirements may be agreed upon at the time of enquiry and order.

### **A.3 Microscopic non-metallic inclusions**

The microscopically determined non-metallic inclusion content shall, when being tested according to an agreed procedure (see for example ISO 4967 and ENV 10247), be within agreed limits.

Examples are given in annex B.

### **A.4 Macroscopic non-metallic inclusion content**

The macroscopic non-metallic inclusions shall, when being tested according to an agreed method (see footnote j to Table 7), be within agreed limits.

### **A.5 Product analysis**

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

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

### **A.6 Special agreements for marking**

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

### **A.7 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.8 Special dimensional inspection**

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

## Annex B (informative)

### Content of microscopic non-metallic inclusions

The characterization of non-metallic inclusions is critically important to the fatigue life of bearings. Several methods for characterization and diagrams may be used such as ISO 4967, ASTM E45, BS 5710, DIN 50602, GOST 1778-70, JIS GO555, NF A04-106, PN 64 H 04510 and SIS 11 11 11.

Tables B.1 and B.2 list the various limits for degrees of purity according to the most widely used standards ASTM E45 and DIN 50602 criteria. The actual criteria, method and limits shall be agreed upon at the time of enquiry and order.

NOTE In the next edition specifications based on ISO 4967 will be included in the main body of this part of ISO 683.

**Table B.1 — Method A – Limits for degree of purity of air-melted through-hardening, case-hardening, induction-hardening and stainless bearing steels<sup>a, b, c</sup>**

Jernkontoret standard diagrams	Through-hardening bearing steels	Case-hardening bearing steels	Induction-hardening bearing steels	Stainless bearing steels
A (fine)	2,5 <sup>d</sup>	2,5 <sup>d</sup>	2,5 <sup>d</sup>	2,5 <sup>d</sup>
A (thick)	1,5 <sup>d</sup>	1,5 <sup>d</sup>	1,5 <sup>d</sup>	2,0 <sup>d</sup>
B (fine)	2,0	2,0	2,0	2,5
B (thick)	1,0	1,0	1,0	2,0
C (fine)	0,5 <sup>e</sup>	0,5	0,5	1,0 <sup>e</sup>
C (thick)	0,5 <sup>e</sup>	0,5	0,5	1,0 <sup>e</sup>
D (fine)	1,0	1,0	1,0	2,0
D (thick)	1,0	1,0	1,0	1,5

<sup>a</sup> Method A of ASTM E45 expresses the results as the average, calculated as the sum of the worst fields (in each sample) for each inclusion type divided by the number of samples.

<sup>b</sup> Method D of ASTM E45 is designed for steel with low inclusion contents, as found in ESR (Electro Slag Remelted), VAR (Air/Vacuum Arc Remelted) and VIM (Vacuum Induction Melted) processed steels.

<sup>c</sup> The values are applicable for a sample with a minimum reduction of 3:1.

<sup>d</sup> These limits are valid for sulfur contents of max. 0,015 %.

<sup>e</sup> Only applicable for Al-killed steels.

**Table B.2 — Method K – Degree of purity of air-melted through-hardening, case-hardening and induction-hardening bearing steels<sup>a, b</sup>**

<b>Bars</b>  diameter $d$ mm	<b>Forged rings or rolled tubes</b>  wall thickness $t$ mm	<b>Characteristic cumulant K factor (oxides) for through- hardening bearing steels</b>	<b>Characteristic cumulant K factor (oxides) for case-hardening and induction- hardening bearing steels</b>
$200 < d$		$K4 \leq 10$	$K4 \leq 20$
$140 < d \leq 200$		$K4 \leq 10$	$K4 \leq 18$
$100 < d \leq 140$	$100 < t$	$K4 \leq 7$	$K4 \leq 16$
$70 < d \leq 100$	$70 < t \leq 100$	$K4 \leq 7$	$K4 \leq 14$
$35 < d \leq 70$	$35 < t \leq 70$	$K4 \leq 6$	$K4 \leq 12$
$17 < d \leq 35$	$17,5 < t \leq 35$	$K3 \leq 7$	$K3 \leq 15$
$8 < d \leq 17$	$8,5 < t \leq 17,5$	$K3 \leq 6$	$K3 \leq 10$
$d \leq 8$	$t \leq 8,5$	$K2 \leq 6$	$K2 \leq 12$
<p><sup>a</sup> For steel Electro Slag Remelted (ESR), Vacuum Induction Melted (VIM), or Air/Vacuum Arc Remelted (VAR) an oxide rating of <math>K1 \leq 6</math> may be expected for all product diameters.</p> <p><sup>b</sup> For steels (except case hardening grades) that are VIM + VAR an oxide rating of <math>K1 \leq 1</math> may be expected for all product diameters. For case hardening steels an oxide rating of <math>K1 \leq 3</math> may be expected.</p>			

## Annex C (informative)

### Designations of comparable steels

**Table C.1 — Designations of the steels given in Tables 3, 5 and 6 and of comparable grades covered in various regional or national standards or designation systems**

ISO 683-17:1999		Steel designations according to	
Number	Name	EN 10027-2:1992	JIS
<b>Through-hardening bearing steels</b>			
B1	100Cr6	1.3505	SUJ2
B2	100CrMnSi4-4	1.3518	SUJ3
B3	100CrMnSi6-4	1.3520	—
B4	100CrMnSi6-6	1.3519	—
B5	100CrMo7	1.3537	—
B6	100CrMo7-3	1.3536	—
B7	100CrMo7-4	1.3538	—
B8	100CrMnMoSi8-4-6	1.3539	—
<b>Case-hardening bearing steels</b>			
B20	20Cr3	1.3559	—
B21	20Cr4	1.7027	SCr420
B22	20MnCr4-2	1.3515	—
B23	17MnCr5	1.3521	—
B24	19MnCr5	1.3523	—
B25	15CrMo4	1.3566	SCM415
B26	20CrMo4	1.3567	SCM420
B27	20MnCrMo4-2	1.3570	—
B28	20NiCrMo2	1.6522	SNCM220
B29	20NiCrMo7	1.3576	SNCM420
B30	18CrNiMo7-6	1.6587	—
B31	18NiCrMo14-6	1.3533	—
B32	16NiCrMo16-5	1.3532	—
<b>Induction-hardening bearing steels</b>			
B40	C56E2	1.1219	S55C
B41	56Mn4	1.1233	—
B42	70Mn4	1.1244	—
B43	43CrMo4	1.3563	SCM440
<b>Stainless bearing steels</b>			
B50	X47Cr14	1.3541	—
B51	X65Cr14	1.3542	—
B52	X108CrMo17	1.3543	SUS440C
B53	X89CrMoV18-1	1.3549	—
<b>High-temperature bearing steels</b>			
B60	80MoCrV42-16	1.3551	—
B61	13MoCrNi42-16-14	1.3555	—
B62	X82WMoCrV6-5-4	1.3553	SKH51
B63	X75WCrV18-4-1	1.3558	SKH2

## Bibliography

- [1] ISO 6508:1986<sup>2)</sup>, *Metallic materials — Hardness test — Rockwell test (scales A-B-C-D-E-F-G-H-K)*.
- [2] EN 10027-2:1992, *Designation Systems for steels — Part 2: Numerical system*.
- [3] ASTM E45-97e1, *Standard Test Methods for Determining the Inclusion Content of Steel*.
- [4] BS 5710:1979, *Methods for macroscopic assessment of the content of non-metallic inclusions in wrought steels*.
- [5] DIN 50602-1985, *Metallographic examination; microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions*.
- [6] GOST 1778-70, *Steel. Metallographic methods for the determination of nonmetallic inclusions*.
- [7] JIS GO555.
- [8] NF A04-106-1984, *Iron and steel. Methods of determination of content of non metallic inclusions in wrought steel. Part II. Micrographic method using standards diagrams*.
- [9] PN 64 H 04510.
- [10] SIS 11 11 11, *Bedömning av slagginneslutningar i stål. Mikrometoder*.

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<sup>2)</sup> This International Standard has been replaced by ISO 6508-1, ISO 6508-2 and ISO 6508-3.





