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**High carbon chromium  
bearing steels**

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**Descriptors** : bearing alloys, alloys, chromium steels, alloy steels, chromium-containing alloys, high-carbon steels, unalloyed steels, rolling bearings

**Reference number** : JIS G 4805 : 1999 (E)

## Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

In this revision, studies and discussion on bearing steels for conformity between **JIS** and corresponding **ISO** Standards, according to the Three-Year Plan for International Conformity of the Agency of Industrial Science and Technology. Since there are the differences in basic of standardization system and requirement for quality (**ISO** specifies the appearance, dimensions and its tolerance upon agreement, while **JIS** does those in details), it is considered that forced conformation might cause confuse on the market.

However, **ISO/DIS 683-17**, *Heat-treated steels, alloy steels and free-cutting steels—Part 17 : Ball and roller bearing steels*, includes widely kind of steel not specified in **JIS**. For the possibility of effect on expanding the standard for bearing use in the future, and for promotion of prevailing **ISO** Standards, **JIS G 4805 : 1999** has adopted the corresponding **ISO** Standard, **ISO/DIS 683-17** in the Annex.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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## High carbon chromium bearing steels

**Introduction** This Standard is the Japanese Industrial Standard, adopting in the text the conventional Japanese Industrial Standard revised in 1990 and also adopting in Annex to this Standard **ISO/DIS 683-17, Heat-treated steels, alloy steels and free-cutting steels—Part 17: Ball and roller bearing steels**, published in 1997, without any modification in its technical content.

**1 Scope** This Japanese Industrial Standard specifies the high carbon chromium bearing steels (hereafter referred to as the “steels”) used for roller bearings. Further, the steels shown in the Annex also comprise a part of this Standard. The Annex is applicable as a substitute for the text.

**2 Normative references** The normative references to this Standard are shown in Attached Table 1. The standards listed in Attached Table 1 contain provisions which, through reference in this Standard, constitute the provisions of this Standard. The most recent edition of the standards listed shall be applied.

**3 Grade and designation** The steels shall be classified into 5 grades and the designation shall be as given in Table 1.

**Table 1 Designation of grade**

Grade designation
SUJ 1
SUJ 2
SUJ 3
SUJ 4
SUJ 5

**4 Chemical composition** The steels are tested in accordance with 14.1 and their cast analysis values shall be as given in Table 2.

**Table 2 Chemical composition**

Unit : %

Grade designation	C	Si	Mn	P	S	Cr	Mo
SUJ 1	0.95 or 1.10	0.15 or 0.35	0.50 max.	0.025 max.	0.025 max.	0.90 to 1.20	—
SUJ 2	0.95 or 1.10	0.15 or 0.35	0.50 max.	0.025 max.	0.025 max.	1.30 to 1.60	—
SUJ 3	0.95 or 1.10	0.40 or 0.70	0.90 to 1.15	0.025 max.	0.025 max.	0.90 to 1.20	—
SUJ 4	0.95 or 1.10	0.15 or 0.35	0.50 max.	0.025 max.	0.025 max.	1.30 to 1.60	0.10 to 0.25
SUJ 5	0.95 or 1.10	0.40 or 0.70	0.90 to 1.15	0.025 max.	0.025 max.	0.90 to 1.20	0.10 to 0.25

**Remarks 1** The steels shall not contain more than 0.25 % of Ni and Cu respectively as impurities. For wire rods, however, the Cu content shall not be more than 0.20 %.

The steels SUJ 1, SUJ 2 and SUJ 3 shall not contain more than 0.08 % of Mo.

- 2 Elements not shown in Table 2 may be added for a maximum of 0.25 % by agreement between the purchaser and manufacturer.
- 3 When a product analysis is carried out in accordance with 14.1, its permissible variation shall conform to Table 3 (Permitted variation on product analysis) of JIS G 0321.

## 5 Shape, dimensions and tolerances

**5.1 Standard dimensions** Standard diameters for the hot-rolled round bars shall be as given in Table 3.

**Table 3 Standard diameter**

Unit : mm

Standard diameter									
15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	(31)	32	33	34
(35)	36	37	38	(39)	40	42	44	46	(48)
49	50	51	(54)	55	60	(64)	65	(66)	70
75	(76)	80	83	(84)	(88)	90	93	99	104
114	(119)	124	130						

Remarks : It is recommended that the use of figures in parentheses be avoided as far as possible for a new design.

**5.2 Dimensional tolerances and ovality of rounds** Dimensional tolerances and the ovality of rounds shall be as given in Table 4 for cold-drawn wires and round bars, while they shall be as given in Table 5 for hot-rolled round bars.

**Table 4 Tolerances on diameter and ovality of round (cold-drawn steels)**

Unit : mm

Cold-drawn wire			Cold-drawn round bar		
Diameter	Tolerance	Ovality of rounds	Diameter	Tolerance	Ovality of rounds
2 or under	± 0.02	0.02 max.	15 or under	± 0.05	0.05 max.
Over 2 up to and incl. 7	± 0.03	0.03 max.	Over 15 up to and incl. 25	± 0.10	0.10 max.
Over 7 up to and incl. 15	± 0.04	0.04 max.	Over 25 up to and incl. 35	± 0.15	0.15 max.
Over 15 up to and incl. 20	± 0.05	0.05 max.			

Remarks : The cold-drawn wires shall refer to those having a round cross-section.

**Table 5 Tolerances on diameter and ovality of rounds (hot-rolled round bars)**

Unit : mm

Hot-rolled round bar		
Diameter	Tolerance	Ovality of rounds
15 or under	$\pm 0.20$	0.30 max.
Over 15 up to and incl. 25	$\pm 0.25$	0.35 max.
Over 25 up to and incl. 35	$\pm 0.30$	0.45 max.
Over 35 up to and incl. 50	$\pm 0.35$	0.50 max.
Over 50 up to and incl. 80	$\pm 0.50$	0.70 max.
Over 80 up to and incl. 100	$\pm 0.75$	1.00 max.
Over 100 up to and incl. 125	$\pm 1.00$	1.50 max.
Over 125 up to and incl. 160	$\pm 1.50$	2.00 max.

**5.3 Unstraightness** Tolerances on unstraightness for cold-drawn round bars and hot-rolled round bars for machining shall be as given in Table 6. For round bars for forging, the steels shall be practically straight.

**Table 6 Tolerances on unstraightness**

Cold-drawn round bar		Hot-rolled round bar	
Diameter	Tolerance	Diameter	Tolerance
35 mm or under	1.0 mm or less in any 1 000 mm length, and 1.0 mm $\times$ overall length (mm)/ 1 000 mm or less for overall length	100 mm or less	1.5 mm or less in any 1 000 mm length, and 1.5 mm $\times$ overall length (mm)/1 000 mm or less for overall length
		Over 100 mm up to and incl. 160 mm	2.0 mm or less in any 1 000 mm length, and 2.0 mm $\times$ overall length (mm)/1 000 mm or less for overall length

**5.4 Others** The permissible variation in shape and dimensional tolerances for other steels than those specified in 5.2 and 5.3 shall be the subject of an agreement between the purchaser and manufacturer.

## 6 Appearance

**6.1 Surface condition** The surface of the steels shall be free from imperfections that are detrimental to practical use.

### 6.2 Allowable limits for flaw and criteria for removal of flaw

**6.2.1 Round bars for machining (hot-rolled round bars)** The allowable limits for the depth of flaw shall be as given in Table 7.

**Table 7 Allowable limits for depth of flaw**

Unit : mm

Diameter	Allowable limit for depth of flaw from the surface of steel
25 or under	0.40 max.
Over 25 up to and incl. 35	0.50 max.
Over 35 up to and incl. 50	0.60 max.
Over 50 up to and incl. 80	0.80 max.
Over 80 up to and incl. 100	1.00 max.
Over 100 up to and incl. 125	1.20 max.
Over 125 up to and incl. 160	1.40 max.

**6.2.2 Round bars for forging (hot-rolled round bars)** The portion where flaw has been removed shall be smooth, and the depth of flaw removal shall not be more than 3 % of nominal sizes (5 mm max.).

Further; the sum of the widths of the flaw-removed portions shall not exceed 1/4 of the circumference in the same cross-section. However, the portion where flaw is removed within the dimensional tolerance shall not be regarded as the trace of flaw removal.

Allowable limits for residual flaw shall be the subject of an agreement between the purchaser and manufacturer.

**6.2.3 Others** The allowable limits for flaw and criteria for the removal of flaw for other steels than those specified in 6.2.1 and 6.2.2 shall be the subject of an agreement between the purchaser and manufacturer.

**7 Total decarburized depth** The spheroidized round bars machining (hot-rolled round bars) and cold-drawn steels shall be tested in accordance with 14.2 and the allowable limits for the total decarburized depth shall be as given in Table 8 or Table 9. For steels other than those specified in Tables 8 and 9, the allowable limits for the total decarburized depth shall be the subject of an agreement between the purchaser and manufacturer.

**Table 8 Allowable limits for total decarburized depth (hot-rolled round bars)**

Unit : mm

Round bar for machining	
Diameter	Total decarburized depth from the surface of steel
25 or under	0.40 max.
Over 25 up to and incl. 35	0.50 max.
Over 35 up to and incl. 50	0.60 max.
Over 50 up to and incl. 80	0.80 max.
Over 80 up to and incl. 100	1.00 max.
Over 100 up to and incl. 125	1.20 max.
Over 125 up to and incl. 160	1.40 max.

**Table 9 Allowable limit for total decarburized depth (cold-drawn steels)**

Unit : mm

Cold-drawn wire		Cold drawn round bar	
Diameter	Total decarburized depth from the surface of steel	Diameter	Total decarburized depth from the surface of steel
7 or under	0.05 max.	15 or under	0.20 max.
Over 7 up to and incl. 15	0.08 max.	Over 15 up to and incl. 25	0.25 max.
Over 15 up to and incl. 20	0.10 max.	Over 25 up to and incl. 35	0.30 max.

**8 Hardness** The hot-finished steels for machining shall be tested in accordance with 14.3, and the hardness of the steels after spheroidizing shall be as given in Table 10.

The hardness of cold-drawn steels and that of low-temperature annealed steels for forging shall be the subject of an agreement between the purchaser and manufacturer.

**Table 10 Hardness**

Grade designation	Hardness of hot-finished steels for machining	
	HB	HRB
SUJ 1, SUJ 2, SUJ 4	201 max.	94 max.
SUJ 3, SUJ 5	207 max.	95 max.

**9 Microstructure** When specified by the purchaser, the microstructure of the steels shall be examined in accordance with 14.4, and the structure shall be as follows :

- a) The microstructure of the spheroidized steels shall have a virtually uniform distribution

of fully spheroidized carbides and shall be free from such defects as segregation bands and huge carbides. The level of the structure shall be as agreed upon between the purchaser and manufacturer.

- b) The microstructure of the steels for forging shall be free from such defects as dense segregation bands and huge carbides. The level of the structure shall be as agreed upon between the purchaser and manufacturer.

**10 Macrostructure** When specified by the purchaser, the macrostructure of the steels shall be examined in accordance with 14.5. The macrostructure shall be free from such defects as pipes, hair cracks, forging cracks and blow holes, and also excessive segregation, dendrites, pits and porosity. The level of the structure shall be as agreed upon between the purchaser and manufacturer.

**11 Non-metallic inclusions** The steels shall be examined in accordance with 14.6 and the degree of purity shall conform to Table 11.

**Table 11 Degree of purity**

Type of non-metallic inclusions	Degree of purity
Type A	0.15 % max.
Type B + Type C	0.05 % max.
Type A + Type B + Type C	0.18 % max.

**12 Macro-streak-flaw** The steels shall be tested in accordance with 14.7, and the number of macro-streak-flaws shall conform to Table 12. However, the steels shall be free from any macro-streak-flaw longer than 4.0 mm.

**Table 12 Number of macro-streak-flaws**

Length of macro-streak-flaw mm	Average of number of macro-streak-flaws (for each step)
Over 0.5 up to and incl. 1.0	5.0 max.
Over 1.0 up to and incl. 2.0	1.0 max.
Over 2.0 up to and incl. 4.0	0.5 max.

**13 Method of manufacture** The method of manufacturing the steels shall be as follows:

- a) The steels shall be manufactured from killed steel produced by applying vacuum degassing to molten metal or the killed steel produced by the process agreed upon between the purchaser and the manufacturer.
- b) The steels shall be manufactured by rolling, forging or other process at the forging ratio of 6 S or more for the steels for machining, and at the forging ratio of 4 S or more for the steels for forging.
- c) Unless otherwise specified, the steels shall be spheroidized.

- d) For the cold-worked steels, hot-finished steels shall be used and cold-drawn steels shall be manufactured by cold drawing, machining, grinding, etc., or a combination of these according to the specification.

## 14 Tests

**14.1 Chemical analysis** The chemical analysis shall be as follows :

- a) General matters for the chemical analysis and the method of sampling for the cast analysis shall be as specified in 3 of **JIS G 0303**.
- b) The method of sampling for the product analysis shall be as specified in 3 of **JIS G 0321**.
- c) The method of analysis shall conform to one of following standards :
- JIS G 1211, JIS G 1212, JIS G 1213, JIS G 1214, JIS G 1215, JIS G 1216, JIS G 1217, JIS G 1218, JIS G 1219, JIS G 1253, JIS G 1256, JIS G 1257, JIS G 1258**

**14.2 Determination of total decarburized depth** The determination of the total decarburized depth shall be as follows:

- a) The method for sampling and the number of test pieces shall be in accordance with Table 13 for the spheroidized steels, while those for the cold-drawn steels shall be as agreed upon between the purchaser and manufacturer.
- b) The method of determination shall conform to **JIS G 0558**.

**Table 13 Method of sampling and number of test pieces**

Type of test	Sampling method and number of test pieces
Determination of total decarburized depth Hardness test Microstructure test	One test piece shall be taken from each of two or more different samples from a lot of steels of the same heat rolled or forged to the same diameter group <sup>(2)</sup> under the same annealing condition in the case of a batch furnace, and one test piece shall be taken from each of two or more samples from every 20 t or a fraction thereof in the case of a continuous furnace.
Non-metallic inclusion test Macro-streak-flaw test Macrostructure test <sup>(1)</sup>	One test piece shall be taken from each of two or more different samples from a lot of steels of the same heat rolled or forged to the same diameter group <sup>(2)</sup> .

Notes <sup>(1)</sup> The micro- and macrostructure tests shall be applied when specified.

<sup>(2)</sup> The same diameter group means a group of the steels having diameters which fall within the ranges given in Table 4 for cold-drawn steels and a group of the steels having diameters which fall within the ranges given in Table 5 for hot-rolled round bars. For the hot-rolled round bars having a diameter more than 160 mm, the sampling method and the number of test pieces shall be the subject of an agreement between the purchaser and manufacturer.

**14.3 Hardness test** The hardness test shall be as follows:

- a) The method of sampling and the number of test pieces shall conform to Table 13 for the hot-rolled and forged steels, and shall be as agreed upon between the purchaser and manufacturer for the cold-drawn steels.
- b) The test method shall be in accordance with **JIS Z 2243** and **JIS Z 2245**.

**14.4 Microstructure test** The microstructure test shall be as follows:

- a) The method of sampling and the number of test pieces shall conform to Table 13.
- b) For testing spheroidized steels, the test surface shall be a longitudinal section including the axis of the steels and the microstructure shall be observed in diametrical direction. However, for the steels having a diameter of 15 mm or under, the cross-section may be the test surface.

For the steels to be machined out into a ring form, the central portion (within a circle having a diameter of 25 % or less of the diameter of the steels) may be exempted from this test.

The test on the steels for forging shall be carried out in the same manner as that on the spheroidized steels.

**14.5 Macrostructure test** The macrostructure test shall be as follows:

- a) The method of sampling and the number of test pieces shall conform to Table 13.
- b) The test method shall be as specified in **JIS G 0553**.

**14.6 Non-metallic inclusion test** The non-metallic inclusion test shall be as follows:

- a) The method of sampling and the number of test pieces shall conform to Table 13.
- b) The test method shall be as specified in **JIS G 0555**.

**14.7 Macro-streak-flaw test** The macro-streak-flaw test shall be as follows:

- a) The method of sampling and the number of test pieces shall conform to Table 13.
- b) The samples shall be turned to have the first-step diameter given in Table 14 (roughness of the finished surface shall normally be 5a). The lengths and number of macro-streak-flaws shall be determined by expressing the length and the number as those per 100 cm<sup>2</sup> of the tested area in accordance with **JIS G 0556**. However, this test shall not be applied to the wire rods and steels 15 mm or under in diameter.

For the steels 160 mm or over in diameter, the test shall be the subject of an agreement between the purchaser and manufacturer.

**Table 14 Dimensions for step machining**

Unit : mm

Hot-rolled round bars					Cold-drawn steels		
Diameter (D)	Diameter in first step	Diameter in second step	Diameter in third step	Length of each step	Diameter (D)	Diameter in first step	Length of a step
Over 15 up to and incl. 25	$D - 2.0$	—	—	63.6	Over 15 up to and incl. 35	$D - 1.0$	63.6
Over 25 up to and incl. 50	$D - 2.5$	$D \times 1/2$	—	63.6			
Over 50 up to and incl. 70	$D - 3.0$	$D \times 1/2$	—	63.6			
Over 70 up to and incl. 100	$D - 3.0$	$D \times 2/3$	$D \times 1/3$	63.6			
Over 100 up to and incl. 160	$D - 4.0$	$D \times 2/3$	$D \times 1/3$	63.6			

Remarks : The macro-streak-flaw test in the second and third steps shall be carried out when specially specified.

**15 Inspection** The inspection shall be as follows :

- a) General matters for inspection shall be as specified in **JIS G 0303**.
- b) Chemical composition shall comply with **4**.
- c) Shape and dimensions shall comply with **5**.
- d) Appearance shall comply with **6**.
- e) The total decarburized depth shall comply with **7**.
- f) The hardness shall comply with **8**.
- g) The non-metallic inclusions shall comply with **11**.
- h) The macro-streak-flaw shall comply with **12**.

Some inspection items listed in **b)** to **h)** may be omitted depending on the type of application with the agreement between the purchaser and the manufacturer.

- i) The microstructure shall be applied when specified by the purchaser, and it shall comply with **9**.
- j) The macrostructure shall be applied when specified by the purchaser, and it shall comply with **10**.

**16 Marking** For the steels that have passed inspection, the following requirements shall be legibly marked on each bundle by a suitable means. However, when requested by the purchaser for the steels not less than 30 mm in diameter or width across flat, these requirements shall be marked on each of the steels.

By agreement between the purchaser and manufacturer, some of these requirements may be omitted.

- a) Designation of grade
- b) Heat number or alternative manufacturing number

c) Manufacturer's name or its abbreviation

**17 Report** The report shall conform to **8** of **JIS G 0303**. However, the report on the micro- and macrostructure shall be the subject to the agreement between the purchaser and manufacturer.

**Attached Table 1 Normative references**

JIS G 0303	<i>General rules for inspection of steel</i>
JIS G 0321	<i>Product analysis and its tolerance for wrought steel</i>
JIS G 0553	<i>Macrostructure detecting method for steel</i>
JIS G 0555	<i>Microscopic testing method for the non-metallic inclusions in steel</i>
JIS G 0556	<i>Method of macro-streak-flaw test for steel</i>
JIS G 0558	<i>Methods of measuring decarburized depth for steel</i>
JIS G 1211	<i>Iron and steel—methods for determination of carbon content</i>
JIS G 1212	<i>Iron and steel—methods for determination of silicon content</i>
JIS G 1213	<i>Methods for determination of manganese in iron and steel</i>
JIS G 1214	<i>Iron and steel—methods for determination of phosphorus content</i>
JIS G 1215	<i>Iron and steel—methods for determination of sulfur content</i>
JIS G 1216	<i>Iron and steel—methods for determination of nickel content</i>
JIS G 1217	<i>Methods for determination of chromium in iron and steel</i>
JIS G 1218	<i>Iron and steel—methods for determination of molybdenum content</i>
JIS G 1219	<i>Iron and steel—methods for determination of copper content</i>
JIS G 1253	<i>Iron and steel—method for spark discharge atomic emission spectrometric analysis</i>
JIS G 1256	<i>Iron and steel—method for X-ray fluorescence spectrometric analysis</i>
JIS G 1257	<i>Iron and steel—methods for atomic absorption spectrometric analysis</i>
JIS G 1258	<i>Methods for inductively coupled plasma emission spectrochemical analysis of steel</i>
JIS Z 2243	<i>Brinell hardness test—Test method</i>
JIS Z 2245	<i>Rockwell hardness test—Test method</i>

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Related standards :

- JIS G 0201 *Glossary of terms used in iron and steel (heat treatment)*
- JIS G 0202 *Glossary of terms used in iron and steel (testing)*
- JIS G 0203 *Glossary of terms used in iron and steel (products and quality)*

**Annex (normative) Heat-treated steels, alloy steels and free-cutting steels—Part 17 : Ball and roller bearing steels**

**Introduction** This Annex is the Japanese Industrial Standard based on **ISO/DIS 683-17, Heat-treated steels, alloy steels and free-cutting steels—Part 17 : Ball and roller bearing steels**, published in 1997, without any modification in its technical content.

This Annex also includes the following Annexes :

- Annex A (normative)      Supplementary or special requirements
- Annex B (informative)    Content of microscopic non-metallc inclusions

## 1 Scope

**1.1** This Annex gives the technical delivery requirements for five groups of wrought ball and rolling bearing steels (hereafter referred to as “bearing steels”) as listed below :

- 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

**1.2** This Annex applies to the products and heat-treatment conditions given in Annex Table 1 and the surface conditions given in Annex Table 2.

**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 Annex, the general technical delivery requirements of **ISO 404** are applicable.

**2 Normative references** The following standards contain provisions which, through reference in this Annex, constitute provisions of this Annex. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Annex are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of **IEC** and **ISO** maintain registers of currently valid International Standards.

- ISO/DIS 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 : 1979 *Steel—Hardenability test by end quenching (Jominy test)*
- ISO 643 : 1983 *Steels—Micrographic determination of the ferritic or austenitic grain size*

ISO 1035-1 : 1980	<i>Hot-rolled steel bars—Part 1: Dimensions of round bars</i>
ISO 1035-4 : 1992	<i>Hot-rolled steel bars—Part 4 : Tolerances</i>
ISO 3763 : 1976	<i>Wrought steels—Macroscopic methods for assessing the content of non-metallic inclusions</i>
ISO 3887 : 1976	<i>Steel, non-alloy and low-alloy—Determination of depth of decarburization</i>
ISO 4948-1 : 1982	<i>Steels—Classification—Part 1 : Classification of steels into unalloyed and alloy steels based on chemical composition</i>
ISO 4967 : 1979	<i>Steel—Determination of content of non-metallic inclusions—Micrographic method using standard diagrams</i>
ISO 4969 : 1980	<i>Steel—Macrographic examination by etching with strong mineral acids</i>
ISO 5949 : 1983	<i>Tool steels and bearing steels—Micrographic method for assessing the distribution of carbides using reference photomicrographs</i>
ISO 6506 : 1981	<i>Metallic materials—Hardness test—Brinell test</i>
ISO 6508 : 1986	<i>Metallic materials—Hardness test—Rockwell test (scales A-B-C-D-E-F-G-H-K)</i>
ISO 6929 : 1987	<i>Steel products—Definitions and classification</i>
ISO 9443 : 1991	<i>Heat-treatable and alloy steels—Surface quality classes for hot-rolled round bars and wire rods—Technical delivery conditions</i>
ISO/TR 9769 : 1991	<i>Steel and iron—Review of available methods of analysis</i>
ISO 10474 : 1991	<i>Steel and steel products—Inspection documents</i>
ISO 14284 : 1996	<i>Steel and iron—Sampling and preparation of samples for the determination of chemical composition</i>
ENV 10247 : 1996	<i>Metallographic test methods—Examination of steels using standard diagrams to assess the content of non-metallic inclusions</i>

**3 Definitions** For the purpose of this Annex, the 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 in an order shall cover the following :

- a) The designation of the product form (e.g. bar) followed by
  - either the designation of the dimensional standard and the dimensions and tolerances selected from this standard (see 5.6) or
  - 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 :
  - the surface condition (see Annex Table 2) and

- the surface quality (see 5.5) ;
- c) A description of the steel comprising
  - a reference to this Annex
  - the designation of the steel type (see Annex Table 3)
  - the symbol for the heat-treatment condition on delivery (see Annex Table 1)
  - the standard designation for the required type of inspection document (see **ISO 10474**)
  - the symbol and, where necessary, the details of each supplementary requirement (see Annex A), if any supplementary requirement shall be complied with.

Example :

The following are to be ordered:

Hot-rolled round bars

according to **ISO 1035-1**

with a nominal diameter of 50.0 mm

with a nominal length of 8 000 mm

with a tolerance on diameter of  $\pm 0.40$  mm (= class S of **ISO 1035-4**)

with a tolerance on length of  $\begin{matrix} -0\text{mm} \\ +100\text{mm} \end{matrix}$  (= class L2 of **ISO 1035-4**)

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

Surface: as hot-worked

Steel: in accordance with the Annex, type 100 Cr6 (see Annex Table 3)

Heat-treatment condition: annealed to achieve spheroidized carbides (symbol +AC, see Annex Table 1)

with an inspection certificate 3.1B (see **ISO 10474**)

Designation :

Rounds **ISO 1035-1** - 50.0 S × 8 000 L2

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

## 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** 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.

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

Annex Table 1 in combination with Annex Table 6 covers for the various product forms

and steel groups usual heat-treatment conditions. Annex Table 2 specifies 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** Annex Table 1 gives a survey on combinations of usual heat-treatment conditions at delivery, product forms and requirements according to the Annex 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 (without +H) of Annex Table 3 and not the designations (with +H) given in Annex Table 5 are applied—the requirements for chemical composition and hardness cited in Annex Table 1, column 10, apply as appropriate for the particular heat-treatment condition. In this case the values of hardenability given in Annex Table 5 are for guidance purposes only.

**5.2.3** Where the steel is, by using the designations given in Annex Table 5, ordered to hardenability requirements, the values of hardenability given in Annex Table 5 apply in addition to the requirements cited in Annex Table 1, column 10 [see Note (2) of Annex 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

- in the case of case hardening steels after holding the steel for 4 h at  $(925 \pm 10) ^\circ\text{C}$ , at least 70 % of the structure revealed according to one of the procedures given in **ISO 643** consists of grains with the size 5 or finer
- in the case of induction hardening steels after holding for 1.5 h at  $(850 \pm 10) ^\circ\text{C}$ , the structure revealed according to one of the procedures given in **ISO 643** consists of grains with the size 5 or finer.

For verification of the grain size, see **1** of Annex A.

### **5.3.2 Spheroidization and distribution of carbides**

- a) For deliveries in treatment conditions +AC and +AC + C, the carbides of the through hardening steels shall be fully 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.
- b) For distribution of carbides, see **2** of Annex A.

**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 3 of Annex A and Annex B.

For macroscopic non-metallic inclusions, see 4 of Annex A.

## **5.5 Surface quality**

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

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

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

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

As long as no International Standard for the machining allowances of ball and roller bearing steel is available, the allowances shall be agreed 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 at the time of enquiry and order. The agreement shall, as far as possible, be based on corresponding International Standards, otherwise, on suitable national standards.

Remarks : For round bars, the following International Standard covers dimensions and/or tolerances for products included in this Annex.

**ISO 1035-1 and ISO 1035-4**

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

### **6.1 Inspection and testing procedures and types of document**

**6.1.1** For each delivery, the issue of any inspection document to **ISO 10474** may be agreed 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 include :

- 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 of the verification of the requirements shall be in accordance with the prescriptions in Annex Table 7.

**6.2.2 Chemical composition** The cast analysis is given by the manufacturer. For product analysis, see 5 of Annex A.

**6.2.3 Verification of hardenability and hardness** The hardness requirements given for the relevant heat-treatment condition in Annex Table 1, column 10, sub-clause 2, shall be verified.

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

**6.2.4 Inspection of the surface quality** Unless otherwise agreed when ordering (see 7 of Annex A), the surface quality shall be inspected visually.

**6.2.5 Dimensional inspection** Unless otherwise agreed when ordering (see 8 of Annex A), the number of products to be inspected for their shape and dimensions is 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 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 6 of Annex A).

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

1	2	3	4	5	6	7	8	9	10	11			
1	Heat-treatment condition at delivery	Symbol	X = Applicable for						Applicable requirements if the steel is ordered with the designation given in				
			billets	bars	rod (small bar)	wire	tubes	rings and discs	Annex Table 3				
									1.	2.	1.	2.	3.
									Chemical composition according to Annex Tables 3 and 4	Maximum hardness or hardness range according to Annex Table 6	As in column 10 [see Note(1) of Annex Table 3]	As in column 10 [see Note(1) of Annex Table 5]	Hardenability values according to Annex Table 5
2	Untreated	None or +U	X	X	X	—	—	—	—	—	—	—	—
3	Treated for cold shearability	+S	X	—	—	—	—	—	—	—	—	—	—
4	Annealed (soft annealed)	+A	—	X	X	—	—	—	—	—	—	—	—
5	Stress relieved	+SR	—	—	—	X	X	—	—	—	—	—	—
6	Treated to hardness range	+HR	—	X	X	—	—	X	—	—	—	—	—
7	Annealed to achieve spheroidized carbides	+AC	—	X	X	X	X	X	—	—	—	—	—
8	Annealed to achieve spheroidized carbides and cold-worked	+AC+C	—	X	—	X	X	X	—	—	—	—	—
9	Isothermally treated to ferrite-pearlite structure and hardness range	+FP	—	X	—	—	—	X	—	—	—	—	—
10	Others	Other treatment conditions, for example the quenched and tempered condition, may be agreed at the time of enquiry and order.											

Annex 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						
2	3	billets		bars	small bar	wire	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	Peeled or turned	PT	—	X	X	—	X	—	
4		Ground	GR	—	X	—	—	—	—	
5		Machined	MA	—	—	—	—	—	X	
6		Cold-drawn	CD	—	—	X	— <sup>(1)</sup>	X	—	
7		Cold-pilgered (rocked)	CP	—	—	—	—	—	X	
8		Cold-rolled	CR	—	—	—	—	—	—	X
9		Others	Others	As agreed	—	—	—	—	—	—

Note (1) Cold-drawn rod is by definition wire (see ISO 6929)

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

No	Type of steel name	Chemical composition (1) (2) % (mass)										Others	
		C	Si	Mn	P max.	S max.	Cr	Mo	Ni	V	W		
Through hardening bearing steels													
B1	100Cr6	0.93 to 1.05 (3)	0.15 to 0.35 (4)	0.25 to 0.45	0.025	0.015 (5)	1.35 to 1.60	max. 0.10					Al : max. 0.050
B2	100CrMnSi4-4	0.93 to 1.05 (3)	0.45 to 0.75	0.90 to 1.20	0.025	0.015 (5)	0.90 to 1.20	max. 0.10					Ca : (6)
B3	100CrMnSi6-4	0.93 to 1.05 (3)	0.45 to 0.75	1.00 to 1.20	0.025	0.015 (5)	1.40 to 1.65	max. 0.10					Cu : max. 0.30
B4	100CrMnSi6-6	0.93 to 1.05 (3)	0.45 to 0.75	1.40 to 1.70	0.025	0.015 (5)	1.40 to 1.65	max. 0.10					
B5	100CrMo7	0.93 to 1.05 (3)	0.15 to 0.35	0.25 to 0.45	0.025	0.015 (5)	1.65 to 1.95	0.15 to 0.30					
B6	100CrMo7-3	0.93 to 1.05 (3)	0.15 to 0.35	0.60 to 0.80	0.025	0.015 (5)	1.65 to 1.95	0.20 to 0.35					
B7	100CrMo7-4	0.93 to 1.05 (3)	0.15 to 0.35	0.60 to 0.80	0.025	0.015 (5)	1.65 to 1.95	0.40 to 0.50					O : max. 0.0015 (7)
B8	100CrMnSi8-4-6	0.93 to 1.05 (3)	0.40 to 0.60	0.80 to 1.10	0.025	0.015 (5)	1.80 to 2.05	0.50 to 0.60					Ti : (8)
Case hardening bearing steels													
B20	20Cr3	0.17 to 0.23	max. 0.40	0.60 to 1.00	0.025	0.015 (5)	0.60 to 1.00						Al : max. 0.0050
B21	20Cr4	0.17 to 0.23	max. 0.40	0.60 to 0.90	0.025	0.015 (5)	0.90 to 1.20						Ca : (6)
B22	20MnCr4-2	0.17 to 0.23	max. 0.40	0.65 to 1.10	0.025	0.015 (5)	0.40 to 0.75						Cu : max. 0.30
B23	17MnCr5	0.14 to 0.19	max. 0.40	1.00 to 1.30	0.025	0.015 (5)	0.80 to 1.10						O : max. 0.0020 (7)
B24	20MnCr5	0.17 to 0.22	max. 0.40	1.10 to 1.40	0.025	0.015 (5)	1.00 to 1.30						Ti : (8)
B25	15CrMo4	0.12 to 0.18	max. 0.40	0.60 to 0.90	0.025	0.015 (5)	0.90 to 1.20	0.15 to 0.25					
B26	20CrMo4	0.17 to 0.23	max. 0.40	0.60 to 0.90	0.025	0.015 (5)	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 (5)	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 (5)	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 (5)	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 (5)	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 (5)	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 (5)	1.00 to 1.40	0.20 to 0.30	3.80 to 4.30				
Induction hardening bearing steels													
B40	C56E2	0.52 to 0.60	max. 0.40	0.60 to 0.90	0.025	0.015 (5)							Al : max. 0.0050
B41	56Mn4	0.52 to 0.60	max. 0.40	0.90 to 1.20	0.025	0.015 (5)							Ca : (6)
B42	70Mn4	0.65 to 0.75	max. 0.40	0.80 to 1.10	0.025	0.015 (5)							Cu : max. 0.30
													O : max. 0.0020 (7)

**Annex Table 3 Types of steel and specified chemical composition (applicable to cast analysis) (concluded)**

No	Type of steel name	Chemical composition (%) (°) % (mass)											Others				
		C	Si	Mn	P max.	S max.	Cr	Mo	Ni	V	W	Ti : (°)					
B43	43CrMo4	0.40 to 0.46	max. 0.40	0.60 to 0.90	0.025	0.015 (°)	0.90 to 1.20	0.15 to 0.30									Ti : (°)
Stainless hardening bearing steels																	
B50	X47Cr14	0.43 to 0.05	max. 1.00	max. 1.00	0.040	0.015 (°)	12.50 to 14.50										
B51	X65Cr14	0.60 to 0.70	max. 1.00	max. 1.00	0.040	0.015 (°)	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 (°)	16.00 to 18.00	0.40 to 0.80									
B53	X90CrMoV18-1	0.85 to 0.95	max. 1.00	max. 1.00	0.040	0.015 (°)	17.00 to 19.00	0.90 to 1.30			0.07 to 0.12						
High temperature bearing steels																	
B60	81MoCrV42-16	0.77 to 0.85	max. 0.40	0.15 to 0.35	0.025 (°)	0.015 (°)	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 : 0.10 (10°)
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

- Notes (1) 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 materials used in manufacture, of elements which affect the hardenability, mechanical properties and applicability.
- (2) In the case of the grades with specified hardenability requirements (see Annex 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  $\pm 0.01$  % and in all other cases the values according to Annex Table 4.
- (3) Other carbon contents within the range of 0.90 % to 1.10 % shall be agreed at the time of enquiry and order.
- (4) By agreement max. 0.15 % Si for cold forming.
- (5) Where machinability is of primary importance, max. 0.030 % sulfur shall be agreed at the time of enquiry and order.
- (6) Intentional additions of calcium or calcium alloys for deoxidation or inclusion shape control are not permitted unless specifically approved by the purchaser.
- (7) Oxygen content applies to product analysis.
- (8) A maximum titanium content shall be agreed at the time of enquiry and order.
- (9) Max. 0.015 % phosphorus and max. 0.008 % sulfur shall be agreed at the time of enquiry and order.
- (10) Max. 0.20 % Cu shall be agreed at the time of enquiry and order.

**Annex Table 4 Permissible deviations between specified analysis and product analysis**

Element	Permissible maximum content according to cast analysis %	Permissible deviation (1) % for				
		through hardening bearing steels	case hardening bearing steels	induction hardening bearing steels	stainless bearing steels	high temperature bearing steels
C	0.60 or under	—	±0.02	±0.02	±0.02	±0.02
	Over 0.60 up to and incl. 1.20	±0.03	—	±0.03	±0.03	±0.03
Si	0.40 or under	±0.03	±0.03	+0.03	—	±0.03
	Over 0.40 up to and incl. 1.00	±0.05	—	—	+0.05	—
Mn	1.00 or under	±0.04	±0.04	±0.04	+0.03	±0.04
	Over 1.00 up to and incl. 1.40	±0.06	±0.06	±0.06	—	—
P	0.040 or under	+0.005	+0.005	+0.005	+0.005	+0.005
S	0.025 or under	+0.005	+0.005	+0.005	+0.005	+0.005
Cr	2.00 or under	±0.05	±0.05	±0.05	—	—
	Over 2.00 up to and incl. 10.00	±0.10	—	—	—	±0.10
	Over 10.00 up to and incl. 15.00	—	—	—	±0.15	—
	Over 15.00 up to and incl. 19.00	—	—	—	±0.20	—
Mo	0.30 or under	±0.03	±0.03	±0.03	—	—
	Over 0.30 up to and incl. 0.60	±0.05	±0.05	—	±0.05	+0.03
	Over 0.60 up to and incl. 1.75	—	—	—	—	—
	Over 1.75 up to and incl. 5.20	—	—	—	—	±0.10
Ni	1.00 or under	—	±0.03	—	+0.03	+0.03
	Over 1.00 up to and incl. 2.00	—	±0.05	—	—	—
	Over 2.00 up to and incl. 4.30	—	±0.07	—	—	±0.07
V	0.50 or under	—	—	—	±0.03	—
	Over 0.50 up to and incl. 1.50	—	—	—	—	±0.05
	Over 1.50 up to and incl. 2.00	—	—	—	—	±0.10
W	0.25 or under	—	—	—	—	±0.03
	Over 5.00 up to and incl. 10.00	—	—	—	—	±0.10
	Over 10.00 up to and incl. 19.00	—	—	—	—	±0.20
Al	0.050 or under	+0.010	+0.010	+0.010	—	—
Cu	0.30 or under	+0.03	+0.03	+0.03	—	+0.03

Note (1) ± means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in Annex Table 3, but not both at the same time.



**Annex Table 6 Hardness in the usual conditions of delivery**

Number	Name	Hardness in the condition of delivery					
		+S	+A	+HR	+AC <sup>(1)</sup>	+AC <sup>(1)</sup> +C	+FP
		HB max.	HB max.	HB	HB max.	HB max.	HB
Through hardening bearing steels							
B1	100Cr6	( <sup>2</sup> )	—	—	207	241 ( <sup>3</sup> ) ( <sup>4</sup> )	—
B2	100CrMnSi4-4	( <sup>2</sup> )	—	—	217	—	—
B3	100CrMnSi6-4	( <sup>2</sup> )	—	—	217	251 ( <sup>4</sup> )	—
B4	100CrMnSi6-6	( <sup>2</sup> )	—	—	217	251 ( <sup>4</sup> )	—
B5	100CrMo7	( <sup>2</sup> )	—	—	217	251 ( <sup>4</sup> )	—
B6	100CrMo7-3	( <sup>2</sup> )	—	—	217	—	—
B7	100CrMo7-4	( <sup>2</sup> )	—	—	230	260	—
B8	100CrMnMoSi8-4-6	( <sup>2</sup> )	—	—	230	—	—
Case hardening bearing steels							
B20	20Cr3	( <sup>5</sup> )	207	156 to 207	170	( <sup>6</sup> )	—
B21	20Cr4	( <sup>5</sup> )	207	156 to 207	170	( <sup>6</sup> )	140 to 187
B22	20MnCr4-2	255	207	163 to 207	170	( <sup>6</sup> )	—
B23	17MnCr5	( <sup>5</sup> )	207	156 to 207	170	( <sup>6</sup> )	140 to 187
B24	20MnCr5	255	217	170 to 217	179	( <sup>6</sup> )	152 to 201
B25	15CrMo4	255	207	156 to 207	170	( <sup>6</sup> )	137 to 184
B26	20CrMo4	255	207	163 to 207	170	( <sup>6</sup> )	146 to 193
B27	20MnCrMo4-2	255	207	156 to 207	170	( <sup>6</sup> )	146 to 193
B28	20NiCrMo2	( <sup>5</sup> )	212	163 to 212	170	( <sup>6</sup> )	149 to 194
B29	20NiCrMo7	255	229	174 to 229	170	( <sup>6</sup> )	154 to 207
B30	18CrNiMo7-6	255	229	179 to 229	179	( <sup>6</sup> )	159 to 207
B31	18NiCrMo14-6	255	—	—	241	( <sup>6</sup> )	—
B32	16NiCrMo16-5	255	—	—	241	( <sup>6</sup> )	—
Induction hardening bearing steels							
B40	C56E2	255 ( <sup>7</sup> )	229	—	—	—	—
B41	56Mn4	255 ( <sup>7</sup> )	229	—	—	—	—
B42	70Mn4	255 ( <sup>7</sup> )	241	—	—	—	—
B43	43CrMo4	255 ( <sup>7</sup> )	241	—	—	—	—
Stainless bearing steels							
B50	X47Cr14	( <sup>8</sup> )	—	—	248	( <sup>6</sup> )	—
B51	X65Cr14	( <sup>8</sup> )	—	—	255	( <sup>6</sup> )	—
B52	X108CrMo17	( <sup>8</sup> )	—	—	255	( <sup>6</sup> )	—
B53	X90CrMoV18-1	( <sup>8</sup> )	—	—	255	( <sup>6</sup> )	—
High temperature bearing steels							
B60	81CrMoV42-16	( <sup>8</sup> )	—	—	248	( <sup>6</sup> )	—
B61	13MoCrNi42-16-14	( <sup>8</sup> )	269	—	—	—	—
B62	X82WMoCrV6-5-4	( <sup>8</sup> )	—	—	248	( <sup>6</sup> )	—
B63	X75WCrV18-4-1	( <sup>8</sup> )	—	—	269	( <sup>6</sup> )	—

- Notes (1) 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.
- (2) If this condition is needed, maximum hardness values and requirements concerning the structure are to be agreed at the time of enquiry and order.
- (3) The hardness of wire for needle bearings may amount up to 321 HB.
- (4) The hardness for cold finished tubes may amount up to 321 HB.
- (5) Under suitable conditions, this grade is shearable in the untreated condition.
- (6) 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 at the time of enquiry and order.
- (7) Depending on the chemical composition of the cast, and on the dimensions condition, +A might be necessary.
- (8) Shearability will in general only apply in condition +AC or in condition +A (for grade 13MoCrNi42-16-14 only).

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

Note : This table only applies, if specific testing is ordered.

1	2	3	4		5	6	7
			Sample products	Number of.			
No	Requirements	Test unit (1)	Sample products	Test pieces per sample	Sampling method, see (2)	Test method, see	
1a	Chemical composition (cast analysis)	C	(3)	(3)	(3)	(3)	
1b	Chemical composition (product analysis)	C	1 or more/cast	1 or more	ISO 14284	(4)	
2	Hardenability in the end-quench test (5)	C	1 or more/cast	1	ISO 642	ISO 642 (6)	
3	Hardness in the condition						
3a	+S	C.T.D (7)	1 for test units of 50 tons or less, 2 for over 50 tons to 100 tons inclusive, 3 for over 100 tons	1	ISO 6506	ISO 6506	
3b	+A	C.T.D (7)					
3c	+HR	C.T.D (7)					
3d	+AC	C.T.D (7)					
3e	+AC+C	C.T.D (7)					
3f	+FP	C.T.D (7)					
4	Structure						
4a	Austenitic grain size	C	1/cast	1	ISO 643	ISO 643	
4b	Spheroidization of carbides	C.T.D (7)	(8)	(8)	(8)	(8)	
4c	Distribution of carbides	C.T.D (7)	(8)	(8)	(8)	ISO 5949	
4d	Microscopic non-metallic inclusions	C.D	(8)	(8)	(8)	(8)	
4e	Macroscopic non-metallic inclusions	C.D	(8)	(8)	(8)	(8)	(10)
5	Surface decarburization (11)	C.T.S.D	(8)	(8)	ISO 3887	ISO 3887	ISO 3887

- Notes (1) 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".
- (2) For all requirements, the general conditions for sampling according to **ISO/DIN 377** apply.
- (3) The cast analysis is given by the manufacturer.
- (4) 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.
- (5) Applies only for case hardening and induction hardening bearing steels.
- (6) Quenching temperature: see Annex Table 5.
- (7) Products of small difference in thickness (about 1:1.5) can be considered as one test unit.
- (8) Shall be agreed at the time of enquiry and order.
- (9) Depending on the agreements at the time of enquiry and order, either according to **ISO 4967** or **ENV 10247**.
- (10) 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 ultrasonic test.
- (11) Applies only for through hardening, stainless and high temperature bearing steels.

## Annex A (normative) Supplementary or special requirements

**Introduction** This Annex A is the Annex to the Japanese Industrial Standard, prepared based on the Annex A to **ISO/DIS 683-17**, *Heat-treated steels, alloy steels and free-cutting steels—Part 17: Ball and roller bearing steels*, published in 1997, without any modification in its technical content and structure.

**Informative** 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 between the purchaser and the manufacturer at the time of enquiry and order.

**A.1 Verification of grain size** In case the verification of the fine grain structure is specified, also the method for the determination of grain size according to **ISO 643** is to be agreed at the time of enquiry and order.

**A.2 Distribution of carbides** The carbides shall be distributed as agreed in accordance with **ISO 5949**. When making such agreements, the steel grade and the size of the product shall be taken into account. In the verification of the carbide distribution is required, the details of this shall also be agreed.

**A.3 Microscopic non-metallic inclusions** The microscopically determined non-metallic inclusion content shall, when being tested according to an agreed procedure (see **ISO 4967** and **ENV 10247**), be within agreed limits.

**A.4 Macroscopic non-metallic inclusion content** The macroscopic non-metallic inclusions shall, when being tested according to an agreed method [see Note <sup>(10)</sup> of Annex Table 7], be within agreed limits.

**A.5 Product analysis** One sample shall be taken for each 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 agreement for marking** The products shall be marked in a way specially agreed at the time of enquiry and order.

**A.7 Surface quality** The surface quality shall comply with the requirements agreed 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 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

**Introduction** This Annex B is the Annex to the Japanese Industrial Standard, prepared based on the Annex B to **ISO/DIS 683-17**, *Heat-treated steels, alloy steels and free-cutting steels—Part 17: Ball and roller bearing steels*, published in 1997, without any modification in its technical content and structure.

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 5 S100**, **DIN 50602**, **GOST 1778-70**, **JIS G 0555**, **NF A04-106**, **PN 64 H 04510** and **SIS 11 11 11**.

The informative Annex B Tables 1 and 2 list the various limits for degree 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.

Remarks : **ISO 4967**: 1979 is at present under revision and it takes some time to gain experience with the revised standard, but in the next edition specifications based on the revised **ISO 4967** will be included in the main body of **ISO 683-17**.

**Annex B Table 1 Method A—Limits for degree of purity of air-melted through hardening, case-hardening, induction hardening and stainless bearing steels <sup>(1)</sup>, <sup>(2)</sup>, <sup>(3)</sup>**

Jernkontoret standard diagrams	Through hardening bearing steels	Case hardening bearing steels	Induction hardening bearing steels	Stainless bearing steels
A (fine)	2.5 <sup>(4)</sup>	2.5 <sup>(4)</sup>	2.5 <sup>(4)</sup>	2.5 <sup>(4)</sup>
A (thick)	1.5 <sup>(4)</sup>	1.5 <sup>(4)</sup>	1.5 <sup>(4)</sup>	2.0 <sup>(4)</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>(5)</sup>	0.5	0.5	1.0 <sup>(5)</sup>
C (thick)	0.5 <sup>(5)</sup>	0.5	0.5	1.0 <sup>(5)</sup>
D (fine)	1.0	1.0	1.0	2.0
D (thick)	1.0	1.0	1.0	1.5

Notes <sup>(1)</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>(2)</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>(3)</sup> The values are applicable for a sample with a minimum reduction of 3 : 1.

(<sup>4</sup>) These limits are valid for sulfur contents of max. 0.015 %.

(<sup>5</sup>) Only applicable for Al-killed steels.

**Annex B Table 2 Method K—Degree of purity of air-melted through hardening, case-hardening and induction hardening bearing steels (<sup>1</sup>), (<sup>2</sup>)**

Diameter of bars mm	Wall thickness of forged rings or rolled tubes <i>t</i> mm	<i>K</i> factor for through hardening bearing steels	<i>K</i> factor for case hardening and induction hardening bearing steels
$200 < d$		$K4 \leq 10$	$K4 \leq 20$
$140 < d \leq 200$		$K4 \leq 10$	$K4 \leq 18$
$100 < d \leq 140$	$100 < t$	$K4 \leq 7$	$K4 \leq 16$
$70 < d \leq 100$	$70 < t \leq 100$	$K4 \leq 7$	$K4 \leq 14$
$35 < d \leq 70$	$35 < t \leq 70$	$K4 \leq 6$	$K4 \leq 12$
$17 < d \leq 35$	$17.5 < t \leq 35$	$K3 \leq 7$	$K3 \leq 15$
$8 < d \leq 17$	$8.5 < t \leq 17.5$	$K3 \leq 6$	$K3 \leq 10$
$d \leq 8$	$t \leq 8.5$	$K2 \leq 6$	$K2 \leq 12$

Notes (<sup>1</sup>) For steel Electro Slag Remelted (ESR), Vacuum Induction Melted (VIM), or Air/Vacuum Arc Remelted (VAR), an oxide rating of *K*1 6 or less may be expected for all product diameters.

(<sup>2</sup>) For steels (except case hardening grades) that are VIM + VAR, an oxide rating of *K*1 1 or less may be expected for all product diameters. For case hardening grades, an oxide rating of *K*1 3 or less may be expected.

Errata for JIS (English edition) are printed in *Standardization Journal*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

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