
INTERNATIONAL STANDARD 683 / XVII

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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 — Dix-septième partie :
Aciers pour roulements*

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 683/XVII was drawn up by Technical Committee ISO/TC 17, *Steel*, and circulated to the Member Bodies in November 1974.

It has been approved by the Member Bodies of the following countries:

Austria	Hungary	Romania
Belgium	India	South Africa, Rep. of
Bulgaria	Iran	Spain
Canada	Ireland	Sweden
Czechoslovakia	Italy	Switzerland
Denmark	Japan	Turkey
Finland	Mexico	U.S.S.R.
France	Netherlands	Yugoslavia
Germany	Poland	

The Member Bodies of the following countries expressed disapproval of the document on technical grounds:

United Kingdom
U.S.A.

Heat-treated steels, alloy steels and free-cutting steels — Part 17 : Ball and roller bearing steels

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard gives specifications for four groups of wrought ball and roller bearings steels as listed in table 4, namely :

- a) steels with about 1 % C and 1 to 2 % Cr, which are referred to in this International Standard as through hardening bearing steels,
- b) case hardening steels,
- c) stainless steels, and
- d) high temperature bearing steels.

1.2 This International Standard applies to the products and heat-treatment and surface conditions given in table 1.

2 REFERENCES

- ISO/R 79, *Brinell hardness test for steel and cast iron.*
- ISO/R 80, *Rockwell hardness test (B and C scales) for steel.*
- ISO/R 81, *Vickers hardness test for steel (load 5 to 100 kgf).*
- ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel.*
- ISO/R 404, *General technical delivery requirements for steel.*
- ISO/R 642, *Hardenability test by end quenching steel (Jominy test).*
- ISO/R 643, *Micrographic determination of the austenitic grain size of steels.*
- ISO/R 1035/I, *Dimensions of hot-rolled steel bars — Round bars — Metric series.*
- ISO 1035/IV, *Dimensions of hot-rolled steel bars — Tolerances of round, square and flat bars — Metric series.*¹⁾
- ISO 3887, *Steel, non-alloy and low-alloy — Determination of depth of decarburization.*¹⁾

1) At present at the stage of draft.

3 REQUIREMENTS

3.1 Production processes

Unless otherwise agreed in the order, the processes used in making the steels and the product are left to the discretion of the manufacturer. When he so requests, the user shall be informed what steelmaking process is being used.

3.2 Types of condition of delivery and specified requirements

3.2.1 For the treatments, surface conditions and products given in table 1, the steels covered by this International Standard shall be ordered and delivered in accordance with tables 1 and 2. In such cases the type of condition of delivery selected according to tables 1 and 2 shall be stated at the time of enquiry and order, and the delivered product when tested in accordance with the conditions summarized in table 3 under columns 3 to 7 shall fulfil those requirements which, according to table 2, columns 2, 3 and 4, correspond to the ordered type of condition of delivery.

Example : If the type of condition of delivery "10 b" is stated in the order the delivery must — as marked in table 2, column 3, under 10 b by "X" — fulfil the requirements cited in table 2, column 4, row 1a, 1b, 3a, 4c and 5b, and for case hardening steels with the exception of steel 16 additionally the requirements in row 4a.

3.2.2 If in special cases heat treatments or surface conditions other than those given in table 1 are required, the type of condition of delivery shall be agreed at the time of enquiry and order.

3.3 Dimensions and tolerances

3.3.1 The dimensions and the tolerances on dimensions and mass in the relevant cases shall be in accordance with ISO/R 1035/I and ISO 1035/IV.

3.3.2 In cases in which no relevant International Standards are available the tolerances on dimensions and mass shall be agreed at the time of enquiry and order.

3.3.3 Rejection will be justified if the dimensional tolerances specified are exceeded.

4 TESTING

4.1 Test conditions

For acceptance tests the test conditions given in table 3 apply.

4.2 Retests

4.2.1 For retests for the product analysis ISO/R 404 is valid.

4.2.2 For retests for mechanical properties ISO/R 404 is valid.

4.3 Certification of the tests

For certification of the tests ISO/R 404 is valid, acceptable documents being as follows :

- statement of compliance with the order, or
- report based on quality control, or
- works certificate, or
- test certificate, or
- certificate of acceptance.

5 RECTIFICATION, INTERNAL DEFECTS AND RECLAIMING

The conditions given in ISO/R 404 are valid for

- rectification,
- internal defects and
- reclaiming.

TABLE 1 – Recommended types of delivery conditions (according to table 2) which are most commonly applicable for the different steels, products, heat treatments and surface conditions

Steel	Group	Type	Recommended types of delivery conditions for																	
			billets		bars				wire		tubes				rings and discs					
			untreated	cold shearable	anneal H 1)	treated for improved machinability	anneal SC 2)	anneal SC 2) + cold drawn	anneal SC 2) + peeled	anneal SC 2) + ground	anneal SC 2)	anneal SC 2) + cold drawn	anneal SC 2)	anneal SC 2) + peeled	anneal SC 2) + cold pilgered	anneal SC 2) + cold drawn	anneal H 1)	treated for improved machinability	anneal SC 2)	anneal SC 2) + machined
Through hardening steels	1		10 20	10b 20b			10e 20e	10f 20f	10e 20e	10e 20e	10e 20e	10f 20f	10e 20e	10e 20e	10f 20f	10f 20f			10e 20e	10e 20e
	2 to 5		10 20	10b 20b			10e 20e		10e 20e				10e ³⁾ 20e ³⁾	10e ³⁾ 20e ³⁾	10f ³⁾ 20f ³⁾	10f ³⁾ 20f ³⁾			10e 20e	10e 20e
Case hardening steels	10 to 15		10 20	10b 20b	10c 20c	10d 20d	10e 20e	10f 20f	10e 20e	10e 20e	10e 20e	10f 20f	10e 20e	10e 20e	10f 20f		10c 20c	10d 20d	10e 20e	10e 20e
	16		10 20	10b 20b	10c 20c	10d 20d	10e 20e	10f 20f									10c 20c	10d 20d	10e 20e	10e 20e
Stainless steels	20 to 21						10e 20e	10f 20f	10e 20e	10e 20e	10e 20e	10f 20f							10e 20e	10e 20e
High temperature bearing steels	30 to 32						10e 20e	10f 20f	10e 20e	10e 20e	10e 20e	10f 20f							10e 20e	10e 20e

1) Anneal H – annealed to achieve a maximum hardness only. This condition applies only to case hardening steels. It is an alternative to the condition "heat treated for improved machinability" used in cases where the steels are intended for machining.

2) Anneal SC – annealed to achieve spheroidized carbides. For case hardening steels 10 to 15 inclusive this condition is applied if cold forming operations are intended. For the other groups of steels this condition is also used if the steel is processed by machining operations.

3) Only valid for steel 4.

Supplement to table 2, column 4 — "Required results"

<p>R4a Austenitic grain size : The steelmaking procedure shall be such that the steel will have a predominant grain size of 5 or finer, though isolated grains as coarse as 3 will be permitted, when tested in accordance with ISO/R 643.</p> <p>R4b Spheroidization of carbides : The carbides of the through hardening steels shall be fully spheroidized and the carbides of the stainless steels 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.</p> <p>R4c Non-metallic inclusions : All bearing steels shall have a high degree of cleanliness, i.e. a low content of non-metallic inclusions. If necessary the corresponding requirements shall be agreed at the time of enquiry and order.</p> <p>R5 Surface quality and decarburization :</p> <ol style="list-style-type: none"> 1) All products shall have a workmanlike finish and shall be clean and free from surface defects likely to have an adverse effect. 2) Peeled, ground or machined products shall be free from surface defects and surface decarburization. 3) For hot-rolled or cold-drawn round bars and wire which are not intended for machining, the following values apply for the permissible depth of surface defects. The values also apply for the permissible depth of decarburization for the steels other than for case hardening : 	<table border="1"> <tr> <th>Diameter (d) mm</th> <th>Permissible depth of defect or decarburization mm</th> </tr> <tr> <td>≤ 15</td> <td>≤ 0,20</td> </tr> <tr> <td>> 15 ≤ 25</td> <td>≤ 0,30</td> </tr> <tr> <td>> 25 ≤ 35</td> <td>≤ 0,40</td> </tr> <tr> <td>> 35 ≤ 50</td> <td>≤ 0,60</td> </tr> <tr> <td>> 50</td> <td>≤ 0,012 5 × d</td> </tr> </table> <p>For other products not intended for machining, the values shall be agreed at the time of enquiry and order.</p> <p>4) Hot-rolled round bars which are intended for machining shall not show any cracks or surface decarburization which are deeper than the machining allowance given in the following :</p> <table border="1"> <tr> <th>Diameter (d) mm</th> <th>Machining allowances* on diameter mm</th> </tr> <tr> <td>< 20</td> <td>≤ 1,2</td> </tr> <tr> <td>> 20</td> <td>≤ 0,03 × d + 0,6</td> </tr> </table> <p>* Only half this allowance is applicable to each of the opposite surfaces.</p> <p>For other products the machining allowances shall be agreed at the time of enquiry and order.</p>	Diameter (d) mm	Permissible depth of defect or decarburization mm	≤ 15	≤ 0,20	> 15 ≤ 25	≤ 0,30	> 25 ≤ 35	≤ 0,40	> 35 ≤ 50	≤ 0,60	> 50	≤ 0,012 5 × d	Diameter (d) mm	Machining allowances* on diameter mm	< 20	≤ 1,2	> 20	≤ 0,03 × d + 0,6
Diameter (d) mm	Permissible depth of defect or decarburization mm																		
≤ 15	≤ 0,20																		
> 15 ≤ 25	≤ 0,30																		
> 25 ≤ 35	≤ 0,40																		
> 35 ≤ 50	≤ 0,60																		
> 50	≤ 0,012 5 × d																		
Diameter (d) mm	Machining allowances* on diameter mm																		
< 20	≤ 1,2																		
> 20	≤ 0,03 × d + 0,6																		

TABLE 2 — Type of delivery conditions and quality requirements specified by them¹⁾

1	2	3											4	
		Type of delivery conditions ⁷⁾												
No.	Requirement	10	10b	10c	10d	10e	10f	20	20b	20c	20d	20e	20f	Required results
1a	Chemical composition (cast analysis)	X	X	X	X	X	X	X	X	X	X	X	X	see table 4
1b	Chemical composition (product analysis)	X	X	X	X	X	X	X	X	X	X	X	X	see table 5
2	Hardenability	-	-	-	-	-	-	-	-	-	-	-	-	see table 6
2a	end-quench test ²⁾	-	-	-	-	-	-	X	X	X	X	X	X	see table 7
2b	reference test bar ³⁾	-	-	-	-	-	-	X	X	X	X	X	X	see table 7
3	Hardness in the condition	-	-	-	-	-	-	-	-	-	-	-	-	see table 8
3a	cold shearable	-	X	-	-	-	-	-	X	-	-	-	-	
3b	anneal H ₄)	-	-	-	-	-	-	-	-	-	-	-	-	
3c	heat treated for improved machinability ²⁾	-	-	-	-	X	-	-	-	-	-	-	X	
3d	anneal SC ⁵⁾	-	-	-	-	-	-	-	-	-	-	-	-	
3e	anneal SC ⁵⁾ + cold drawn	-	-	-	X	-	-	-	-	-	X	-	-	
4	Structure	-	-	-	-	-	-	-	-	-	-	-	-	see R4a
4a	Austenitic grain size ⁶⁾	X	X	X	X	X	X	X	X	X	X	X	X	see R4a
4b	Spheroidization of carbides	-	-	-	-	X	X	-	-	-	-	X	X	see R4b
4c	Content of non-metallic inclusions	X	X	X	X	X	X	X	X	X	X	X	X	see R4c
5a	Surface decarburization ³⁾	-	-	-	-	X	X	X	X	X	X	X	X	see R5
5b	Surface quality	X	X	X	X	X	X	X	X	X	X	X	X	see R5

- 1) See 3.2.1.
- 2) Only applicable to case hardening steels.
- 3) Only applicable to through hardening, stainless and high temperature bearing steels.
- 4) Anneal H — annealed to achieve a maximum hardness only. This condition applies only to case hardening steels. It is an alternative to the condition "heat treated for improved machinability" used in cases where the steels are intended for machining.
- 5) Anneal SC — annealed to achieve spheroidized carbides for case hardening steels 10 to 15 inclusive. This condition is applied if cold forming operations are intended. For the other group of steels this condition is also used if a steel is processed by machining operations.
- 6) Only applies to case hardening steels with the exception of steel 16.
- 7) The type numbers for delivery conditions are preliminary. It is intended that they will be finalized as soon as the International Standard on a system of identifying types of delivery conditions has been established.

TABLE 3 – Test unit, number of sample products and test pieces and sampling and test methods for the different requirements

1	2	3	4	5	6	7
No.	Requirement	Test unit ¹⁾	Number of		Sampling ²⁾ see	Test method see
			sample products	test pieces per sample product		
1a	Chemical composition (cast analysis)	C	3)	3)	3)	3)
1b	Chemical composition (product analysis)	C	≥ 1/cast	≥ 1	ISO/R 377	4)
2	Hardenability					
2a	end-quench test ⁵⁾	C	1/cast	1	ISO/R 642	ISO/R 642 7)
2b	reference test bar ⁶⁾	C	1/cast	1	8)	8)
3	Hardness in the condition					
3a	cold shearable	C, T, D ⁹⁾	1, 2 resp. 3 for test units of ≤ 50 t, > 50 ≤ 100 t resp. > 100 t	1	ISO/R 79	ISO/R 79
3b	anneal H	C, T, D ⁹⁾				
3c	heat treated for improved machinability	C, T, D ⁹⁾				
3d	anneal SC	C, T, D ⁹⁾				
3e	anneal SC + cold drawn	C, T, D ⁹⁾				
4	Structure					
4a	austenitic grain size ⁵⁾	C	1/cast	1	ISO/R 643	ISO/R 643
4b	spheroidization of carbides	C, T, D ⁹⁾	10)	10)	10)	10)
4c	content of non-metallic inclusions	C, D	10)	10)	10)	10)
5a	Surface decarburization ⁶⁾	C, T, S, D	10)	10)	11)	11)
5b	Surface quality	C, S, D	all products	whole product	10)	10)

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/R 377 apply.

3) The cast analysis, if ordered, 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. 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 steels.

6) Applies only for through hardening, stainless and high temperature bearing steels.

7) Quenching temperatures : see table 9, column 3.

8) A test piece of 12,5 ± 0,5 mm diameter shall be taken from the product according to the rules of ISO/R 642. After quenching and tempering according to table 9, the test piece shall be hardness tested in accordance with ISO/R 80, or ISO/R 81.

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

10) Shall be agreed at the time of enquiry and order.

11) In cases of dispute chips shall be taken in accordance with ISO 3887, and the depth of decarburization shall be measured as the distance between the surface and that zone in which the carbon content is equal to 90% of the lower carbon limit given for the corresponding steel type in table 4.

TABLE 4 – Types of steel and chemical composition guaranteed (applicable to cast analysis) 1) 2)

Type of steel	C %	Si %	Mn %	P % max.	S % max.	Cr %	Mo %	Ni %	V %	W %
Through hardening bearing steels										
1	0,95/1,10	0,15/0,35	0,25/0,45	0,030	0,025	1,35/1,65	—	—	—	—
2	0,95/1,10	0,45/0,75	0,95/1,25	0,030	0,025	0,90/1,20	—	—	—	—
3	0,95/1,10	0,45/0,75	0,95/1,25	0,030	0,025	1,40/1,65	—	—	—	—
4	0,95/1,10	0,20/0,40	0,25/0,45	0,030	0,025	1,65/1,95	0,20/0,40	—	—	—
5	0,95/1,10	0,20/0,40	0,60/0,90	0,030	0,025	1,65/1,95	0,20/0,40	—	—	—
Case hardening bearing steels										
10	0,13/0,19	0,15/0,40	1,00/1,30	0,035	0,035	0,80/1,10	—	—	—	—
11	0,17/0,23	0,15/0,40	0,40/0,70	0,035	0,035	—	0,20/0,30	1,60/2,00	—	—
12	0,17/0,23	0,15/0,40	0,60/0,90	0,035	0,035	0,35/0,65	0,15/0,25	0,40/0,70	—	—
13	0,17/0,23	0,15/0,40	0,40/0,70	0,035	0,035	0,35/0,65	0,15/0,25	0,90/1,20	—	—
14	0,17/0,23	0,15/0,40	0,40/0,70	0,035	0,035	0,35/0,65	0,20/0,30	1,60/2,00	—	—
15	0,14/0,20	0,15/0,40	0,60/0,90	0,035	0,035	0,80/1,10	0,15/0,25	1,20/1,60	—	—
16	0,14/0,20	0,15/0,40	0,40/0,70	0,035	0,035	1,30/1,60	0,15/0,25	3,25/3,75	—	—
Stainless bearing steels										
20	0,42/0,50	1,00 max.	1,00 max.	0,040	0,030	12,5/14,5	—	1,00 max.	—	—
21	0,95/1,20	1,00 max.	1,00 max.	0,040	0,030	16,0/18,0	0,35/0,75	0,50 max.	—	—
High temperature bearing steels										
30	0,77/0,85	0,25 max.	0,35 max.	0,025	0,020	3,75/4,25	4,00/4,50	—	0,90/1,10	—
31	0,78/0,86	0,40 max.	0,40 max.	0,030	0,030	3,80/4,50	4,70/5,20	—	1,70/2,00	6,00/6,70
32	0,70/0,80	0,40 max.	0,40 max.	0,030	0,030	3,75/4,50	0,60 max.	—	1,00/1,25	17,5/19,0

1) Elements not quoted in this table shall not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall 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.

2) If ordered to conditions of delivery, 20, 20b, 20c, 20d, 20e, 20f, the specified hardenability should be the governing criteria for acceptance. In such cases, the cast analysis may deviate slightly from the figures shown in table 4.

3) By agreement between the producer and the user, steels 1 to 5 may be ordered with an upper limit of sulphur greater than 0,025 %.

TABLE 5 – Permissible deviations between specified ranges of analysis and product analysis

Type of steel	Permissible deviations ^{1) 2)}									
	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %	V %	W %
1	± 0,03	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	—	—	—	—
2 and 3	± 0,03	± 0,03	± 0,06	+ 0,005	+ 0,005	± 0,05	—	—	—	—
4	± 0,03	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,04	—	—	—
5	± 0,03	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,04	—	—	—
10	± 0,02	± 0,03	± 0,06	+ 0,005	+ 0,005	± 0,05	—	—	—	—
11	± 0,02	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,03	± 0,05	—	—
12	± 0,02	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,03	± 0,03	—	—
13	± 0,02	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,03	± 0,05	—	—
14	± 0,02	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,03	± 0,05	—	—
15	± 0,02	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,03	± 0,05	—	—
16	± 0,02	± 0,03	± 0,04	+ 0,005	+ 0,005	± 0,05	± 0,03	± 0,07	—	—
20	± 0,02	+ 0,05	+ 0,03	+ 0,005	+ 0,005	± 0,15	—	+ 0,03	—	—
21	± 0,03	+ 0,05	+ 0,03	+ 0,005	+ 0,005	± 0,20	± 0,05	+ 0,03	—	—
30	± 0,03	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,10	± 0,10	—	± 0,05	—
31	± 0,03	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,10	± 0,10	—	± 0,10	± 0,10
32	± 0,03	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,10	+ 0,03	—	± 0,05	± 0,20

1) ± means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in table 4, but not both at the same time.

2) Applicable for diameters ≤ 160 mm or sections with an equivalent area.

TABLE 6 – Tentative hardness limits^{1) 2)} for specified hardenability of case hardening steels

Distance from quenched end of test piece	Hardness HRC													
	steel 10		steel 11		steel 12		steel 13		steel 14		steel 15		steel 16	
mm	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
1,5	38	46	40	48	40	48	41	48	41	48	39	47	39	47
3	36	46	36	45	37	47	39	47	38	47	38	46	39	47
5	32	44	27	41	32	44	30	42	34	45	36	45	39	47
7	29	42	23	37	27	41	25	37	30	42	33	44	38	46
9	26	39	21	33	23	35	22	33	27	39	31	44	38	46
11	24	37	—	29	—	32	20	29	25	36	29	43	38	46
13	22	34	—	27	—	30	—	27	23	34	27	42	38	46
15	20	33	—	25	—	29	—	26	22	32	26	41	37	46
20	—	30	—	22	—	26	—	24	20	29	23	38	37	46
25	—	28	—	21	—	24	—	22	—	26	21	36	36	46
30	—	27	—	21	—	23	—	21	—	25	20	35	34	45
35	—	27	—	20	—	23	—	21	—	24	20	34	33	45
40	—	27	—	20	—	22	—	20	—	24	—	34	32	44
45	—	26	—	20	—	22	—	—	—	24	—	33	31	44
50	—	25	—	—	—	22	—	—	—	24	—	33	30	43

1) The hardness values are tentative and may be adjusted as more information becomes available. The hardness values are based on steels having a grain size of 5 and finer, as defined in ISO/R 643.

2) For quenching temperatures, see table 9.

TABLE 7 – Hardenability of the through hardening, the stainless and the high temperature bearing steels measured as hardness in the quenched and tempered condition¹⁾

Type of steel	Hardness	
	HRC min.	HV min.
Through hardening bearing steels		
1	61	725
2 and 3	61	725
4	61	725
5	61	725
Stainless bearing steels		
20	54	585
21	58	660
High temperature bearing steels		
30	60	700
31	62	750
32	62	750

1) For temperatures and quenching medium, see table 9.