UDC 669.14/.15.018.298.3

Ref. No. : ISO/R 683/I-1968 (E)

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 683 / I

HEAT-TREATED STEELS, ALLOY STEELS AND FREE-CUTTING STEELS

PART I

QUENCHED AND TEMPERED UNALLOYED STEELS

1st EDITION
March 1968

Printed in Switzerland

Also issued in French and Russian. Copies to be obtained through the national standards organizations.

BRIEF HISTORY

The ISO Recommendation R 683/I, *Heat-treated steels, alloy steels and free-cutting steels – Part I : Quenched and tempered unalloyed steels,* was drawn up by Technical Committee ISO/TC 17, *Steel,* the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question by the Technical Committee began in 1958 and led, in 1965, to the adoption of a Draft ISO Recommendation.

In January 1966, this Draft ISO Recommendation (No. 916) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Argentina	Germany	Romania
Australia	Hungary	Spain
Austria	India	Sweden
Belgium	Israel	Switzerland
Brazil	Italy	Turkey
Canada	Japan	U.A.R.
Chile	Korea, Rep. of	United Kingdom
Czechoslovakia	Netherlands	U.S.A.
Denmark	Norway	U.S.S.R.
Finland	Poland	Yugoslavia

One Member Body opposed the approval of the Draft :

France

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council which decided, in March 1968, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 683/1 March 1968

HEAT-TREATED STEELS, ALLOY STEELS AND FREE-CUTTING STEELS

PART I
QUENCHED AND TEMPERED UNALLOYED STEELS

1. SCOPE

1.1 This ISO Recommendation covers unalloyed wrought steels for mechanical purposes usually intended for use

(*a*) in the quenched and tempered condition, or

(*b*) in the austempered condition,

with or without subsequent cold reduction.

1.2 For the purpose of simplification the steels covered by this ISO Recommendation in both conditions are called 'quenched and tempered steels', and both conditions are summarized under the term 'quenched and tempered'.

1.3 This ISO Recommendation comprises the two series of steels, listed in Table 2, which differ in their maximum phosphorus and sulphur contents.

2. REQUIREMENTS

2.1 Production processes

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

2.2 Chemical composition and mechanical properties

2.2.1 The steels covered by this ISO Recommendation should be ordered and delivered in accordance with Table 1.

TABLE 1 – Types of condition of delivery

Requirements	Types of condition of delivery*							
	1	1(a)	3	3(a)	4	4(a)	5	6
Chemical composition	X	X	X	X	X	X	X	X
Hardness in a condition of delivery other than quenched and tempered	–	X	–	X	–	X	–	–
Mechanical properties of								
– quenched and tempered test bars of 16 mm diameter	–	–	X	X	–	–	–	–
– quenched and tempered ruling sections	–	–	–	–	X	X	–	–
– quenched and tempered product in final dimensions	–	–	–	–	–	–	X	–
– quenched and tempered product subsequently cold-reduced to final dimensions	–	–	–	–	–	–	–	X

* The numbers indicating the types of condition of delivery follow a co-ordinated series of numbers throughout all relevant ISO Recommendations.

The type of condition of delivery according to Table 1 should be stated at the time of enquiry and order.

2.2.2 The chemical composition expressed by the cast analysis should be in accordance with Table 2.

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

Type of steel	C %	Si %	Mn %	P % max.	S % max.
C 25 C 25 e	0.22 to 0.29	0.15 to 0.40	0.40 to 0.70	0.050 0.035	0.050 0.035
C 30 C 30 e	0.27 to 0.34	0.15 to 0.40	0.50 to 0.80	0.050 0.035	0.050 0.035
C 35 C 35 e	0.32 to 0.39	0.15 to 0.40	0.50 to 0.80	0.050 0.035	0.050 0.035
C 40 C 40 e	0.37 to 0.44	0.15 to 0.40	0.50 to 0.80	0.050 0.035	0.050 0.035
C 45 C 45 e	0.42 to 0.50	0.15 to 0.40	0.50 to 0.80	0.050 0.035	0.050 0.035
C 50 C 50 e	0.47 to 0.55	0.15 to 0.40	0.60 to 0.90	0.050 0.035	0.050 0.035
C 55 C 55 e	0.52 to 0.60	0.15 to 0.40	0.60 to 0.90	0.050 0.035	0.050 0.035
C 60 C 60 e	0.57 to 0.65	0.15 to 0.40	0.60 to 0.90	0.050 0.035	0.050 0.035

* Elements not quoted in Table 2 should not be intentionally added to the steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions should be taken to prevent the addition, from scrap or other materials used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

2.2.2.1 If ordered to condition of delivery type 1 or 1(a) (see Table 1), the following permissible deviations between the values specified in Table 2 and the product analysis of products up to 160 mm (6.3 in) diameter apply. Above 150 mm (5.9 in) square section, the permissible deviations should be stated at the time of enquiry and order.

TABLE 3 – **Permissible deviations between specified analysis and product analysis**

Type of steel	Permissible deviations*				
	C %	Si %	Mn %	P %	S %
C 25, C 25 e	± 0.02	± 0.03	± 0.04	+ 0.005	+ 0.005
C 30, C 30 e C 35, C 35 e C 40, C 40 e C 45, C 45 e C 50, C 50 e	± 0.03				
C 55, C 55 e C 60, C 60 e	± 0.04				

* ± means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in Table 2 but not both at the same time.

2.2.2.2 If ordered to condition of delivery types 3, 3(a), 4, 4(a), 5 and 6, the mechanical properties specified in Table 4 (page 7) and Table 5 (page 8) should be the governing criteria for acceptance. In such cases, the cast analysis may deviate slightly from the values shown in Table 2.

2.2.3 If specified, the mechanical properties should be those shown in Table 4 or Table 5.

2.2.3.1 The values apply to test pieces, taken on rounds in the direction of the metal fibre, the axis of the test piece corresponding to that shown in Figure 1 (page 10).

2.2.3.2 For rectangular sections, the ranges for equivalent diameters are given in Figure 2 (page 11).

2.2.3.3 For other sections, the equivalent diameter should be agreed at the time of enquiry and order.

2.2.4 The mechanical properties in the quenched and tempered conditions as given in Table 4 are those which can be obtained for one of the conditions given below :

(1) For a reference test bar of 16 mm diameter, taken from the product to be delivered either by machining from a location according to Figure 1 or by forging, and then quenched and tempered according to the temperatures and times listed in Table 7 (page 9) (types of condition of delivery 3 and 3(a) of Table 1).

(2) For a ruling section,* to be specified at the time of enquiry and order, which is quenched and tempered according to the temperatures listed in Table 7 (types of condition of delivery 4 and 4(a) of Table 1).

For location of the test bar, see clause 3.2.1.

(3) For the product in the quenched and tempered condition of delivery (type of condition of delivery 5 of Table 1).

For location of the test bar, see clause 3.2.1.

2.2.5 The mechanical properties in the quenched and tempered and subsequently cold-reduced condition as given in Table 5 may be agreed for the product to be delivered in this condition (type of condition of delivery 6 of Table 1).

For location of the test bar, see clause 3.2.1.

2.2.6 If the products are delivered in a condition other than quenched and tempered, with or without subsequent cold reduction, a maximum hardness in accordance with Table 6 (page 9), measured after preparation of the surface in the conventional manner, may be agreed in addition to the other requirements (types of condition of delivery 1(a), 3(a) and 4(a) of Table 1).

2.3 Tolerances on dimensions and mass

The tolerances allowable on dimensions and mass should be stated in the order, as long as there are no ISO Recommendations to cover them.

3. TESTING

3.1 Number of sample products

3.1.1 *Chemical composition.* The cast analysis is given by the manufacturer. If a product analysis is required by the purchaser, at least one sample product should be taken from each cast.

3.1.2 *Mechanical properties*

3.1.2.1 For material not supplied in the finally heat-treated condition (types of condition of delivery 3, 3(a), 4 and 4(a) of Table 1), one sample product should be taken from each cast for testing in accordance with the requirements of Table 4 or Table 6.

* In the selection of a steel, one of the most important considerations is whether the mechanical properties required can be obtained from the steel in the size and shape at the time of heat treatment. That portion, which is most important from the point of view of the mechanical properties obtained by heat treatment, is referred to as the ruling section, and the ruling section should always be expressed in terms of the diameter of an equivalent round bar (see Fig. 1).

3.1.2.2 For material supplied in either the finally heat-treated condition (type of condition of delivery 5 of Table 1) or in the heat-treated and subsequently cold-reduced condition (type of condition of delivery 6 of Table 1), one sample product should be taken from each size grouping from each heat-treatment batch for testing in accordance with Tables 4 and 5. If the product is continuously heat treated, one sample product for each 25 t or part thereof, but at least one sample product for each cast, should be taken.

3.2 Samples and test pieces

3.2.1 The test pieces for tensile test and impact test should be taken in the longitudinal direction of the products according to Figure 1.

3.2.2 For product analyses, the selection of test samples should be carried out in conformity with the requirements of ISO Recommendation R 377, *Selection and preparation of samples and test pieces for wrought steel.*

3.2.3 General conditions for selection and preparation of test samples and test pieces for steel should be in accordance with ISO Recommendation R 377.

3.3 Test methods

3.3.1 The tensile test should be made in accordance with the following ISO Recommendations :

R 82, *Tensile testing of steel,*
R 86, *Tensile testing of steel sheet and strip less than 3 mm and not less than 0.5 mm thick,*
R 89, *Tensile testing of steel wire.*

3.3.2 The impact test should be made in accordance with ISO Recommendation R 83, *Charpy impact test (U-notch) for steel.* Unless otherwise specified at the time of enquiry and order, the impact value should be determined by the arithmetic average of the results obtained by the breaking of three test pieces next to one another in the test sample or test bar.

3.3.3 The Brinell hardness test should be made in accordance with ISO Recommendation R 79 (2nd edition), *Brinell hardness test for steel.*

3.3.4 In cases of dispute, the methods for the chemical analyses should be those established by the relevant ISO Recommendations. If no ISO Recommendations are available, the methods may be agreed upon and specified at the time of enquiry and order.

3.4 Retests

3.4.1 For retests for mechanical properties, clause 6.5 of ISO Recommendation R 404, *General technical delivery requirements for steel,* is valid.

3.4.2 For retests for the product analysis, clause 7.6 of ISO Recommendation R 404 is valid.

3.5 Certification of the tests

For certification of the tests, section 4 of ISO Recommendation R 404 is valid, acceptable documents being namely

- statement of compliance with the order (see clause 4.1.1), or
- report based on quality control (see clause 4.1.2), or
- works certificate (see clause 4.1.3), or
- test certificate (see clause 4.2.1), or
- certificate of acceptance (see clause 4.2.2).

4. DEFECTS AND DIMENSIONAL TOLERANCES

The conditions given in section 8 of ISO Recommendation R 404 are valid for

- surface defects (see clause 8.1),
- rectification (see clause 8.2),
- internal defects (see clause 8.3),
- dimensional tolerances (see clause 8.4) and
- reclaiming (see clause 8.5).

TABLE 4 – **Mechanical properties for quenched and tempered condition***

Type of steel	$\phi \leqslant 16$ mm (0.63 in)				16 mm (0.63 in) $< \phi \leqslant 40$ mm (1.58 in)				40 mm (1.58 in) $< \phi \leqslant 100$ mm (3.94 in)			
	R_e min.	R_m	A min.	KCU min.	R_e min.	R_m	A min.	KCU min.	R_e min.	R_m	A min.	KCU min.
	kgf/mm² (tonf/in²)	kgf/mm² (tonf/in²)	%	kgf.m/cm²	kgf/mm² (tonf/in²)	kgf/mm² (tonf/in²)	%	kgf.m/cm²	kgf/mm² (tonf/in²)	kgf/mm² (tonf/in²)	%	kgf.m/cm²
C 25 and C 25 e	37 (23.5)	55 to 70 (34.5 to 44.4)	19	– 7	31 (19.7)	50 to 65 (31.7 to 41.3)	21	– 7	–	–	–	–
C 30 and C 30 e	40 (25.4)	59 to 74 (37.5 to 47)	18	– 6	34 (21.6)	55 to 70 (34.5 to 44.4)	20	– 6	30** (19)	50 to 65** (31.7 to 41.3)	21**	– 6**
C 35 and C 35 e	43 (27.3)	63 to 78 (40 to 49.5)	17	– 5	37 (23.5)	59 to 74 (37.5 to 47)	19	– 5	33 (20.9)	55 to 70 (34.5 to 44.4)	20	– 5
C 40 and C 40 e	46 (29.2)	67 to 82 (42.6 to 52.1)	16	– 4	40 (25.4)	63 to 78 (40 to 49.5)	18	– 4	35 (22.2)	59 to 74 (37.5 to 47)	19	– 4
C 45 and C 45 e	49 (31.1)	71 to 86 (45.1 to 54.6)	14	– 3	42 (26.7)	67 to 82 (42.6 to 52.1)	16	– 3	38 (24.1)	63 to 78 (40 to 49.5)	17	– 3
C 50 and C 50 e	52 (33)	75 to 90 (47.6 to 57.1)	13	–	45 (28.6)	71 to 86 (45.1 to 54.6)	15	–	41 (26)	67 to 82 (42.6 to 52.1)	16	–
C 55 and C 55 e	55 (34.9)	80 to 95 (50.8 to 60.3)	12	–	47 (29.8)	75 to 90 (47.6 to 57.1)	14	–	43 (27.3)	71 to 86 (45.1 to 54.6)	15	–
C 60 and C 60 e	58 (36.8)	85 to 100 (54.0 to 63.5)	11	–	50 (31.7)	80 to 95 (50.8 to 60.3)	13	–	46 (29.2)	75 to 90 (47.6 to 57.1)	14	–

* R_e = yield stress (0.2 % proof stress)
R_m = tensile strength
A = percentage elongation after fracture ($L_o = 5\ d_o$)
KCU = impact strength with U-notch

** Up to 63 mm (2.5 in) maximum diameter.

TABLE 5 – **Mechanical properties for the quenched and tempered and subsequently cold-reduced condition***

Type of steel	$\phi \leqslant 16$ mm (0.63 in)			16 mm (0.63 in) $< \phi \leqslant 40$ mm (1.58 in)			40 mm (1.58 in) $< \phi \leqslant 100$ mm (3.94 in)		
	R_e min.	R_m	A min.	R_e min.	R_m	A min.	R_e min.	R_m	A min.
	kgf/mm² (tonf/in²)	kgf/mm² (tonf/in²)	%	kgf/mm² (tonf/in²)	kgf/mm² (tonf/in²)	%	kgf/mm² (tonf/in²)	kgf/mm² (tonf/in²)	%
C 25 and C 25 e	51 (32.4)	63 to 79 (40 to 50.1)	11	47 (29.8)	58 to 74 (36.8 to 47)	14	–	–	–
C 30 and C 30 e	54 (34.3)	68 to 84 (43.2 to 53.3)	10	51 (32.4)	63 to 79 (40 to 50.1)	14	47 (29.8)	58 to 74 (36.8 to 47)	16
C 35 and C 35 e	58 (36.8)	72 to 88 (45.7 to 55.9)	10	54 (34.3)	68 to 84 (43.2 to 53.3)	13	51 (32.4)	63 to 79 (40 to 50.1)	15
C 40 and C 40 e	62 (39.4)	76 to 92 (48.2 to 58.4)	9	58 (36.8)	72 to 88 (45.7 to 55.9)	12	54 (34.3)	68 to 84 (43.2 to 53.3)	14
C 45 and C 45 e	65 (41.3)	80 to 96 (50.8 to 60.9)	9	62 (39.4)	76 to 92 (48.2 to 58.4)	11	58 (36.8)	72 to 88 (45.7 to 55.9)	13
C 50 and C 50 e	68 (43.2)	85 to 101 (54 to 64.1)	8	65 (41.3)	80 to 96 (50.8 to 60.9)	10	62 (39.4)	76 to 92 (48.2 to 58.4)	12
C 55 and C55 e	72 (45.7)	90 to 106 (57.1 to 67.3)	7	68 (43.2)	85 to 101 (54 to 64.1)	9	65 (41.3)	80 to 96 (50.8 to 60.9)	11
C 60 and C 60 e	76 (48.2)	95 to 111 (60.3 to 70.5)	7	72 (45.7)	90 to 106 (57.1 to 67.3)	8	68 (43.2)	85 to 101 (54 to 64.1)	10

* R_e = yield stress (0.2 % proof stress)
R_m = tensile strength
A = percentage elongation after fracture ($L_o = 5\ d_o$).