

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION R 683 / IX

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

PART 9
WROUGHT FREE-CUTTING STEELS

1st EDITION

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BRIEF HISTORY

The ISO Recommendation R 683/IX, *Heat-treated steels, alloy steels and free-cutting steels – Part 9: Wrought free-cutting 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 led to the adoption of Draft ISO Recommendation No. 1364, which was circulated to all the ISO Member Bodies for enquiry in December 1967. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Hungary	South Africa, Rep. of
Austria	India	Spain
Belgium	Israel	Sweden
Canada	Italy	Switzerland
Colombia	Korea, Rep. of	Thailand
Czechoslovakia	Netherlands	Turkey
Denmark	New Zealand	U.A.R.
Finland	Norway	U.S.A.
France	Poland	U.S.S.R.
Germany	Romania	

The following Member Bodies opposed the approval of the Draft :

Brazil
United Kingdom

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

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

PART 9 WROUGHT FREE-CUTTING STEELS

1. SCOPE

- 1.1 This ISO Recommendation covers three groups of wrought free-cutting steels for mechanical purposes as listed in Table 3, namely,
- (a) not intended for heat treatment,
 - (b) suitable for case hardening,
 - (c) suitable for quenching and tempering.
- 1.2 This ISO Recommendation applies to semi-finished products, bars, wire rods, and bright steel.

2. DEFINITION

Free-cutting steels are characterized by good machinability, i.e. high metal removal rate, essentially obtained by higher than normal contents of sulphur, or sulphur and lead.

3. REQUIREMENTS

3.1 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. When he so requests, the user should be informed what steelmaking process is being used.

3.2 Chemical composition and mechanical properties

- 3.2.1 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(b)	1(n)	1(q)	3	3(b)	4	4(b)	5	6
Chemical composition	X	X	X	X	X	X	X	X	X	X
Hardness (maximum value)										
— in the "as rolled" or "as peeled" condition	—	X	—	—	—	X	—	X	—	—
— in the normalized condition	—	—	X	—	—	—	—	—	—	—
Mechanical properties										
— in the normalized condition	—	—	X	—	—	—	—	—	—	—
— in the cold-drawn condition	—	—	—	X	—	—	—	—	—	—
— in the quenched and tempered condition										
— for a 16 mm diameter test bar	—	—	—	—	X	X	—	—	—	—
— for a ruling section	—	—	—	—	—	—	X	X	—	—
— for a product in final dimensions**	—	—	—	—	—	—	—	—	X	—
— in the quenched and tempered and subsequently cold-drawn condition	—	—	—	—	—	—	—	—	—	X
— in the simulated case-hardened condition***	—	—	—	—	—	—	—	—	X	—

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

** For the quenched and tempered steels 7, 8, 9 and 10.

*** For the case-hardening steels 4, 4Pb, 5 and 6.

3.2.2 For the steels covered by this ISO Recommendation, the relevant types of condition of delivery, detailed in Table 1, are appropriate for the types of steel as given in Table 2.

TABLE 2 – Types of steel and related conditions of delivery

Type of steel	Type of condition of delivery
1, 2, 2Pb, 3, 3Pb	1, 1(b), 1(n), 1(q)
4, 4Pb, 5, 6	1, 1(q), 5
7, 8, 9, 10	1, 1(b), 3, 3(b), 4, 4(b), 5, 6

The type of condition of delivery according to Tables 1 and 2 should be stated at the time of enquiry and order.

3.2.3 The chemical composition expressed by the cast analysis should be in accordance with Table 3.

TABLE 3 – Types of steel and chemical composition guaranteed
(applicable to cast analysis)*

Type of steel	C %	Si %	Mn %	P % max.	S %	Pb %
Non-heat-treatable steels						
1	0.13 max.	0.05 max.	0.60 to 1.20**	0.11	0.18 to 0.25	–
2	0.14 max.	0.05 max.	0.90 to 1.30	0.11	0.24 to 0.32	–
2Pb	0.14 max.	0.05 max.	0.90 to 1.30	0.11	0.24 to 0.32	0.15 to 0.35
3	0.15 max.	0.05 max.	1.0 to 1.50	0.11	0.30 to 0.40	–
3Pb	0.15 max.	0.05 max.	1.0 to 1.50	0.11	0.30 to 0.40	0.15 to 0.35
Case-hardening steels						
4	0.07 to 0.13	0.15 to 0.40	0.50 to 0.90	0.06	0.15 to 0.25	–
4Pb	0.07 to 0.13	0.15 to 0.40	0.50 to 0.90	0.06	0.15 to 0.25	0.15 to 0.35
5	0.09 to 0.15	0.15 to 0.40	0.90 to 1.20	0.06	0.15 to 0.25	–
6	0.14 to 0.20	0.15 to 0.40	0.50 to 0.90	0.06	0.15 to 0.25	–
Quenched and tempered steels						
7	0.32 to 0.39	0.15 to 0.40	0.50 to 0.90	0.06	0.15 to 0.25	–
8	0.32 to 0.39	0.15 to 0.40	0.90 to 1.20	0.06	0.15 to 0.25	–
9	0.32 to 0.39	0.15 to 0.40	1.30 to 1.65	0.06	0.15 to 0.25	–
10	0.42 to 0.50	0.15 to 0.40	0.50 to 0.90	0.06	0.15 to 0.25	–

* Elements not quoted in Table 3 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 mechanical properties and applicability.

** A manganese content of 0.50 % min. can be agreed between purchaser and supplier.

- 3.2.3.1 If ordered to types of condition of delivery 1 or 1(b) (see Table 1), the following permissible deviations between the values specified in Table 3 and the product analysis of products up to 160 mm (6.3 in) diameter should apply. Above 160 mm (6.3 in) diameter, the permissible deviations should be stated at the time of enquiry and order.

TABLE 4 — Permissible deviations between specified analysis and product analysis

Type of steel	Permissible deviations*					
	C %	Si %	Mn %	P %	S %	Pb %
1	+ 0.02	0	± 0.06	+ 0.02	± 0.03**	—
2	+ 0.02	0	± 0.06	+ 0.02	± 0.03	—
2Pb	+ 0.02	0	± 0.06	+ 0.02	± 0.03	0
3	+ 0.02	0	± 0.06	+ 0.02	± 0.04	—
3Pb	+ 0.02	0	± 0.06	+ 0.02	± 0.04	0
4	± 0.02	± 0.03	± 0.04	+ 0.008	± 0.03	—
4Pb	± 0.02	± 0.03	± 0.04	+ 0.008	± 0.03	0
5	± 0.02	± 0.03	± 0.06	+ 0.008	± 0.03	—
6	± 0.02	± 0.03	± 0.04	+ 0.008	± 0.03	—
7	± 0.03	± 0.03	± 0.04	+ 0.008	± 0.03	—
8	± 0.03	± 0.03	± 0.06	+ 0.008	± 0.03	—
9	± 0.03	± 0.03	± 0.06	+ 0.008	± 0.03	—
10	± 0.03	± 0.03	± 0.04	+ 0.008	± 0.03	—

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

** A permissible deviation of ± 0.05 % S for type of steel 1 may be agreed between the purchaser and the supplier.

- 3.2.3.2 If ordered to types of condition of delivery 1(n), 1(q), 3, 3(b), 4, 4(b), 5 and 6, the mechanical properties specified in Tables 5, 6 and 7 should be the governing criteria for acceptance. In such cases, the cast analysis may deviate slightly from the values shown in Table 3.

3.3 Hardness

- 3.3.1 If the products are delivered in the types of condition of delivery 1(b) or 1(n) of Table 1, the maximum hardness as shown in Tables 5 and 7 should apply.

- 3.3.2 If the products suitable for quenching and tempering are delivered in a condition other than quenched and tempered, with or without subsequent cold reduction, a maximum hardness measured after preparation of the surface in the conventional manner, in accordance with Table 7, can be agreed in addition to the other requirements (types of condition of delivery 3(b) and 4(b) of Table 1).

3.4 Mechanical properties

3.4.1 If specified, the mechanical properties should be those shown in Tables 5, 6 or 7.

The values apply to test pieces taken in the direction of the metal fibre, the axis of the test piece corresponding to that shown in Figure 1.

3.4.2 If the products are delivered in the normalized or cold-drawn condition (types of condition of delivery 1(n) or 1(q) of Table 1) the values stated in Tables 5 and 6 should apply for test pieces taken in accordance with clause 4.2.1.2.

3.4.3 For the simulated case-hardened condition (type of condition of delivery 5 of Table 1), the figures shown in Table 6 are valid for one reference test bar – of 11 mm or 30 mm diameter as stated in the order – which has been taken from the product in accordance with clause 4.2.1.3 and simulated case-hardened as specified in Table 9.

3.4.4 The mechanical properties in the quenched and tempered conditions as given in Table 7 are those which can be obtained for one of the conditions given below :

3.4.4.1 For a reference test bar of 16 mm diameter, taken from the product to be delivered either by machining from a location according to Figures 1(c) or 1(h) or by forging, and then quenched and tempered according to the temperatures and times listed in Table 10 (types of condition of delivery 3 and 3(b) of Table 1).

3.4.4.2 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 10 (types of condition of delivery 4 and 4(b) of Table 1).

For location of the test bar, see clause 4.2.1.3.

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

For location of the test bar, see clause 4.2.1.3.

3.4.5 The mechanical properties in the quenched and tempered and subsequently cold-reduced condition as given in Table 7 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 4.2.1.3.

3.4.5.1 The values in Table 7 refer to diameters. Rectangular sections should be converted to equivalent diameters by means of Figure 2.

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

3.5 Weldability

Because of their high sulphur and phosphorus content, free-cutting steels are not normally recommended for welding.

3.6 Machinability

The steels covered by this ISO Recommendation have good machinability and chip breaking characteristics. However, the machinability decreases with increasing carbon, silicon and manganese contents, while cold reduction improves the machinability.

3.7 Surface conditions

The surface conditions should be agreed at the time of enquiry and order.

3.8 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.

* 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).

4. TESTING

4.1 Number of sample products

4.1.1 *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.

4.1.2 *Mechanical properties and hardness*

4.1.2.1 For non-heat-treatable steels 1, 2, 2Pb, 3 and 3Pb, the number of tests to be applied will depend upon whether the tests are conducted on the basis of

- (a) a lot*, or
- (b) a cast.

The basis of testing should be agreed at the time of enquiry and order.

One test sample should be taken from each size range shown in Table 5. Each testing batch should comprise

- (a) 20 t or fraction thereof for testing by lots, or
- (b) 40 t or fraction thereof for testing by casts.

4.1.2.2 In the case of steels 4, 4Pb, 5, 6, 7, 8, 9 and 10, the basis of testing should be the cast as follows :

- (a) For steels not supplied in the finally heat-treated condition (types of condition of delivery 1(q), 3, 3(b), 4, 4(b) and 5 of Table 1) and for case-hardening steels, one test sample from each cast.
- (b) For quenched and tempered steels supplied in 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 (see Table 7). If the product is continuously heat-treated, one sample product for each 25 t or part thereof, but at least one sample for each cast, should be taken.

4.2 Samples and test pieces

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

4.2.1.1 For steels 1, 2, 2Pb, 3 and 3Pb, the test sample should consist of a length of the product for small sizes. For larger sizes, the test sample should be so taken that the axis lies as near as possible

- (a) for a cylindrical product, at $\frac{1}{3}$ of the half diameter (see Fig. 1(a));
- (b) for a non-cylindrical product, at $\frac{1}{3}$ of the half width (see Fig. 1(b)).

4.2.1.2 For case-hardening steels, the mechanical properties in the simulated case-hardened condition should be obtained on a reference test bar of 11 mm or 30 mm manufactured by hot forging the test sample to the nearest smaller diameter for the reference test bar. The axis of the test piece should correspond to the axis of the test bar.

For case-hardening steels tested in the cold-drawn condition (type of condition of delivery 1(q) of Table 1), the requirements of clause 4.2.1.1 should apply.

4.2.1.3 For steels suitable for quenching and tempering, the test pieces should be taken in accordance with Figures 1(c) to 1(h). For types of delivery condition 3, 3(b), 4 and 4(b) of Table 1, the requirements of clauses 3.4.4.1 and 3.4.4.2 should apply.

4.2.2 General conditions for selection and preparation of test samples and test pieces for steel should be in accordance with ISO Recommendation R 377, *Selection and preparation of samples and test pieces for wrought steels*.

* A lot is defined as the product of several casts of similar type of steel rolled into one class of product and submitted for inspection at the same time.

4.3 Test methods

4.3.1 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*.

4.3.2 The Brinell hardness test should be made in accordance with ISO Recommendation R 79*, *Brinell hardness test for steel*.

4.3.3 In cases of dispute, the methods for the chemical analysis 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.

4.4 Retests

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

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

4.5 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).

5. 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).

* 2nd Edition, 1968.

TABLE 5 — Mechanical properties for non-heat-treatable free-cutting steels*

Type of steel	Diameter	As rolled or As peeled	Normalized				Cold-drawn		
		Hardness	Hardness	R_e min.	R_m	A min.	R_e min.	R_m	A min.
	mm	HB max.	HB max.	kgf/mm ² (tonf/in ²)	kgf/mm ² (tonf/in ²)	%	kgf/mm ² (tonf/in ²)	kgf/mm ² (tonf/in ²)	%
1	≤ 16	163					40 (25.4)	50 to 80 (31.7 to 50.8)	8
	> 16 ≤ 40	159					36 (22.8)	45 to 75 (28.7 to 47.6)	9
	> 40 ≤ 63	159	145	21 (13.3)	37 to 50 (23.5 to 31.7)	22	30 (19.0)	40 to 70 (25.4 to 44.4)	10
	> 63 ≤ 100	149					24 (15.2)	37 to 62 (23.5 to 39.4)	11
2, 2Pb	≤ 16	170					42 (26.6)	52 to 82 (33.0 to 52.1)	7
	> 16 ≤ 40	159					38 (24.1)	47 to 77 (29.8 to 48.9)	8
	> 40 ≤ 63	159	152	22 (13.9)	39 to 52 (24.7 to 33.0)	20	31 (19.7)	42 to 72 (26.6 to 45.7)	9
	> 63 ≤ 100	156					25 (15.8)	39 to 64 (24.7 to 40.6)	10
3, 3Pb	≤ 16	174					44 (27.9)	55 to 85 (34.9 to 53.9)	7
	> 16 ≤ 40	163					40 (25.4)	50 to 80 (31.7 to 50.8)	8
	> 40 ≤ 63	159	155	23 (14.6)	40 to 53 (25.4 to 33.6)	19	32 (20.3)	44 to 74 (27.9 to 46.9)	9
	> 63 ≤ 100	156					26 (16.5)	40 to 65 (25.4 to 41.3)	10

- * R_e = yield stress (0.2 % proof stress)
 R_m = tensile strength
 A = percentage elongation after fracture ($L_0 = 5 d_0$)

TABLE 6 — Mechanical properties for case-hardening free-cutting steels*

Type of steel	Cold-drawn				Simulated case-hardened			
	Diameter	R_e min.	R_m	A min.	Test bar	R_e min.	R_m	A min.
	mm	kgf/mm ² (tonf/in ²)	kgf/mm ² (tonf/in ²)	%	mm	kgf/mm ² (tonf/in ²)	kgf/mm ² (tonf/in ²)	%
4, 4Pb	≤ 16	40 (25.4)	50 to 80 (31.7 to 50.8)	8	11	33 (20.9)	55 to 90 (34.9 to 57.1)	12
	> 16 ≤ 40	36 (22.8)	45 to 75 (28.6 to 47.6)	9				
	> 40 ≤ 63	30 (19.0)	40 to 70 (25.4 to 44.5)	10	30	27 (17.1)	45 to 75 (28.6 to 47.6)	14
	> 63 ≤ 100	—	—	—				
5	≤ 16	42 (26.7)	52 to 82 (33.0 to 52.0)	7	11	45 (28.6)	70 to 105 (44.4 to 66.7)	8
	> 16 ≤ 40	38 (24.1)	47 to 77 (29.8 to 48.9)	8				
	> 40 ≤ 63	31 (19.7)	42 to 72 (26.6 to 45.7)	9	30	35 (22.2)	55 to 85 (34.9 to 53.9)	10
	> 63 ≤ 100	—	—	—				
6	≤ 16	42	55 to 85 (34.9 to 53.9)	7	11	40 (25.4)	65 to 100 (41.3 to 63.5)	8
	> 16 ≤ 40	38	50 to 80 (31.7 to 50.8)	8				
	> 40 ≤ 63	30	45 to 75 (28.6 to 47.6)	9	30	30 (19.0)	50 to 80 (31.7 to 50.8)	10
	> 63 ≤ 100	—	—	—				

* R_e = yield stress (0.2 % proof stress)

R_m = tensile strength

A = percentage elongation after fracture ($L_0 = 5 d_0$)

TABLE 7 — Mechanical properties of quenched and tempered free-cutting steels*

Type of steel	Diameter	As rolled or As peeled	Quenched and tempered			Quenched and tempered and subsequently cold-drawn		
		Hardness	R_e min.	R_m	A min.	R_e min.	R_m	A min.
	mm	HB max.	kgf/mm ² (tonf/in ²)	kgf/mm ² (tonf/in ²)	%	kgf/mm ² (tonf/in ²)	kgf/mm ² (tonf/in ²)	%
7	≤ 16	197	40 (25.4)	58 to 78 (36.8 to 49.5)	14	55 (34.9)	67 to 83 (42.5 to 52.7)	9
	> 16 ≤ 40	192	34 (21.6)	55 to 75 (34.9 to 47.6)	16	51 (32.4)	63 to 79 (40.0 to 50.1)	12
	> 40 ≤ 63	192	31 (19.7)	50 to 70 (31.7 to 44.4)	17	49 (31.1)	60 to 76 (38.1 to 48.2)	13
	> 63 ≤ 100	—	—	—	—	—	—	—
8	≤ 16	205	43 (27.3)	63 to 83 (40.0 to 52.7)	14	58 (36.8)	72 to 88 (45.7 to 55.8)	9
	> 16 ≤ 40	200	37 (23.5)	60 to 80 (38.1 to 50.8)	16	54 (34.3)	68 to 84 (43.1 to 53.3)	12
	> 40 ≤ 63	200	34 (21.6)	55 to 75 (34.9 to 47.6)	17	52 (33.0)	65 to 81 (41.3 to 51.4)	13
	> 63 ≤ 100	—	—	—	—	—	—	—
9	≤ 16	229	52 (33.0)	75 to 95 (47.6 to 60.3)	12	66 (41.9)	80 to 100 (50.8 to 63.5)	8
	> 16 ≤ 40	223	48 (30.5)	68 to 88 (43.2 to 55.8)	14	63 (40.0)	73 to 93 (46.4 to 59.1)	10
	> 40 ≤ 63	223	45 (28.6)	63 to 83 (40.0 to 52.7)	15	58 (36.8)	68 to 88 (43.2 to 55.9)	12
	> 63 ≤ 100	217	45 (28.6)	63 to 83 (40.0 to 52.7)	15	58 (36.8)	68 to 88 (43.2 to 55.9)	12
10	≤ 16	229	46 (29.2)	66 to 86 (41.9 to 54.6)	11	62 (39.4)	75 to 95 (46.7 to 60.3)	8
	> 16 ≤ 40	223	39 (24.7)	62 to 82 (39.3 to 52.1)	13	59 (37.4)	71 to 91 (45.1 to 57.8)	10
	> 40 ≤ 63	223	35 (22.2)	58 to 78 (36.8 to 49.5)	14	56 (35.5)	69 to 89 (43.8 to 56.5)	11
	> 63 ≤ 100	—	—	—	—	—	—	—

* R_e = yield stress (0.2 % proof stress) R_m = tensile strength A = percentage elongation after fracture ($L_0 = 5 d_0$)

TABLE 8 – Temperature for normalizing the non-heat-treatable free-cutting steels

Type of steel	Normalizing °C
1	900 to 930
2, 2Pb	890 to 920
3, 3Pb	880 to 910

TABLE 9 – Conditions for heat treating the case-hardening free-cutting steels

The temperatures given below for case-hardening are for guidance, but the actual temperatures chosen should be those that will give the properties required. However, the conditions given for the simulated case-hardening of test bars are mandatory.

Type of steel	Case-hardening					Simulated case-hardening		
	Carburizing °C	Core-hardening °C	Case-hardening °C	Quenching medium	Tempering* °C	Quenching °C	medium	Tempering* °C
4, 4Pb 5 6	880 to 950	870 to 910	770 to 810	Water	150 to 200	880 to 900	Water	180

* Time for tempering as a guide : 1 hour minimum.

TABLE 10 – Conditions for heat treating the quenched and tempered free-cutting steels

The temperatures given below are for guidance, but the actual temperatures chosen should be those that will give the properties required.

Type of steel	Annealing °C	Normalizing °C	Quenching* °C		Tempering** °C
				medium	
7, 8	650 to 700	860 to 890	860 to 890	Water or oil	540 to 680
9	650 to 700	—	840 to 870	Oil	540 to 680
10	650 to 700	840 to 870	840 to 870	Oil or water	540 to 680

* Time for austenitizing as a guide : 0.5 hour minimum.

** Time for tempering as a guide : 1 hour minimum.